

ECOLOGICAL STUDIES ON AMBELA PASS, BUNER, N.W.F.P. PAKISTAN.

BY

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**DEPARTMENT OF BOTANY
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بسم الله الرحمن الرحيم

**IN THE NAME OF
"ALLAH"**

**The Most Merciful
The Most Gracious**

DEDICATION

**I DEDICATE THIS WORK TO THE GLORY OF
ISLAMIA COLLEGE PESHAWAR
WHERE I WAS EDUCATED AND WHICH I AM
SERVING SINCE 1962.**

ECOLOGICAL STUDIES ON
AMBELA PASS, BUNER,
N.W.F.P. PAKISTAN

A thesis submitted in partial fulfillment
of the requirements for the
degree of
DOCTOR OF PHILOSOPHY
in
BOTANY

By

SYED SARDAR HUSSAIN SHAH

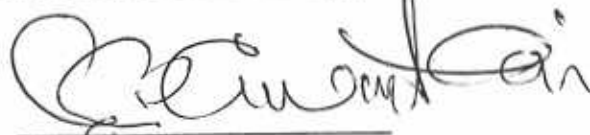
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TABLE OF CONTENTS

ACKNOWLEDGEMENT	i
ABSTRACT	ii
INTRODUCTION	1
Description of Research Area	2
Historical importance of the area	4
Geology	6
Geomorphology	7
Hydrology	9
Soils	9
Climate	11
REVIEW OF LITERATURE	13
MATERIALS AND METHODS	16
RESULTS AND DISCUSSION	19
Stream Vegetation	31
North-Facing Aspect	40
Lower slopes	40
Middle Slopes	50
South-Facing Aspect	58
Lowermost Slopes	59
Lower Slopes	67
Middle Slopes	75
Upper Slopes	80
East-Facing Aspect	87
Lower Slopes	88
Middle Slopes	93
Upper Slopes	101
Vegetation of the Meadows	107
Coefficient of Similarity of the Communities	125
Lower Slopes	125
Middle Slopes	126
Upper Slopes	127
Distribution of the major woody dominants on different Aspects	130
<i>Dodonaea viscosa</i>	130
<i>Mallotus philippensis</i>	139
<i>Pinus roxburghii</i>	149
Species Diversity	159
CONCLUSIONS	171
RECOMMENDATIONS	174
LITERATURE CITED	176

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ABSTRACT

An ecological study of the mountains flanking Ambela Pass, Buner sub Division, NWFP, Pakistan was carried out to bring on record the vegetation of the area and to ascertain the present state of vegetation. Ambela Pass runs in an east-west direction and is flanked by two mountains with north-, south- and east-facing aspects. These aspects were further discernable into three separate zones on the basis of plant communities they supported; and lower, a middle and an upper slope. The north-facing mountain, however, was of a comparatively lower elevation presenting only the lower and middle slopes while the south-facing mountain supported an additional lower-most slope dominated mostly by *Justicia adhatoda* and *Helicteres isora*. At the base of the Pass, there flows a perpetual stream supporting its own set of vegetation dominated by *Arundo donax*.

The study was carried out both in spring and fall seasons and it was found out that the number of species and the number of individuals of each species in fall season was about 2/3rd of those recorded in spring.

The soil varied from sandy loam to loamy sand and was slightly acidic. Its saturation percentage ranged between 30-49, the electrical conductivity between 0.1-0.5 and the organic matter between 0.62-2.45.

The major woody dominants of the lower slopes were *Mallotus philippensis* and *Dodonaea viscosa* while on the middle and upper slopes *Pinus roxburghii* became the leading dominant with *Dodonaea viscosa* as the understorey dominant shrub which, however, was replaced by *Berberis lycium* on the upper slopes.

The herbaceous dominant members varied not only with different season but also with different elevations. They mostly included grasses like *Themeda anathera*, *Setaria pumila*, *Poa infirma* and *Aristida cyanantha* and some herbs like *Oxalis corniculata*, *Rumex hastatus* and *Geranium ocellatum*.

The area, as a whole, was under a high biotic pressure. Overgrazing (particularly by goats), trampling by heavy ungulates and fuel wood extraction were very common. Even pines were indiscriminately pollarded and lumbered due to which their reproduction and survival rates were low. The general vegetation was heading towards a scrub forest type.

INTRODUCTION

Beside other factors, the economy of a country also depends in general on the percent area under forest or, to be more specific, upon the state of the vegetation it is upholding. The archaic land use practices of man since time immemorial, has wrought bewildering transformations in the landscapes and are increasingly threatening the vegetation. Heavy indiscriminate lumbering of trees and slashing of plants for fuel coupled with uncontrolled fires and overgrazing are the root causes of all this evil. The situation is further aggravated by the "wiseman's" activities of construction of roads and establishment of industries in virgin or hitherto unexplored areas, under the cloak of economic development. Even so if all these activities remain well within limits, the ecosystem, with the help of its homeostatic quality, sustains them or repairs any small damage caused to it but the blemish and blasphemes use of the environmental resources by a geometrically growing human population takes it to a point of no return. The results are obvious.

No doubt people living in certain areas have but few alternatives. They totally depend on agricultural and live-stock products and to meet their daily requirements they, slash, burn and clear their surroundings to procure pieces of land for cultivation or to cope with their fuel and shelter problems. But in doing so they little realize the irrevocable and irretrievable changes they are causing to the ecosystem. Many sites give a mute testimony of the desecrate treatment received through the human hands. Even forests do not regenerate due to the trampling effect of large ungulates.

Controlled and mixed grazing is not harmful; if any-thing, it is beneficial (Branson and Miller, 1981). It is the uncontrolled grazing, particularly by goats, which creates problems. Goats are less selective in their forage and will eat almost any plant or its part including twigs fruits, bark or even fallen litter in times of scarcity. They can climb and reach

places where other animals cannot. Their reproductive cycle is shorter than that of sheep and other domestic animals and cover more distance in search of forage than sheep (Hanjra, 1986). The animals not only remove vegetation but the denuded soils become prone to erosion by the impact of their hooves. The top soil usually rich in organic matter is washed away by heavy rains which not only makes the soil infertile but also creates silting problems for dams and causes choking of rivers and streams. These soils cannot sustain vegetation and the site presents a desolate and dreary look proving the proverbial phrase "Forests precede mankind, deserts follow in its wake" true.

Nearly one third of the land surface has become desert and the rest is destined to become so if the state of affairs go unchecked and proper measures are not adopted for the restoration and afforestation of these bare lands on a large scale.

It was this objective in mind that the present study was undertaken. This study deals with the composition and distribution of vegetation of the area, factors responsible for its degradation and with some recommendations for its restoration. At the same time this study will also help in introducing this rich but hitherto unexplored flora to the world in general and interested research workers in particular who may wish to further pursue their studies in this area.

DESCRIPTION OF RESEARCH SITE

Ambela Pass is located in the mountainous region of Buner Tehsil, Malakand Division, NWFP, Pakistan at $34^{\circ} 24'$ longitude and $72^{\circ} 38'$ latitude and is about 24 air km from district Mardan. A metalled road connecting Rustam Town of Mardan Division with Swat via the famous Pir Baba valley passes through it. The pass runs in an east-west direction and is flanked by mountains of different elevations. These mountains present three clear aspects, the north,

south- and east-facing. The west facing aspect is negligible as the mountain spreads up into numerous finger like spurs of very low elevations. These spurs have carved many suitable dwelling sites for the local people who have managed to procure land for cultivation here and there by removing the natural vegetation from comparatively flat topography. Water is also abundantly available here. The area was thus highly disturbed and was therefore excluded from this study.

The north and south facing mountains flanking the pass, run parallel to each other in a zigzag manner. The pass is about 8 km long and 20-30 m wide at the base. At the eastern end of the pass a police check post, a rest house and a mosque were present while at the western end the gorge opens up abruptly and joins a dry stream (khawar) which receives water only in the rainy seasons. At the common base of these two mountains a ravine 20-30 m wide was formed. The ravine started from the rest house at about 825 m elevation and steeped down along low and high gradients to end in khawar at about 540 m elevation. Approximately 1.5 km downward from the rest house and at about 680 m elevation, a large water fall joined the ravine. Later two or more smaller ones also joined it as a result of which a large stream developed which meandered through the pass and vanished in the high sand bed of the khawar. Along its course the stream supported a different set of vegetation mainly dominated by *Arundo donax* while the stretch of land between the first water fall and the rest house was soaked due to the seepage of water from the bases of the two hills. Here *Arundo donax* was totally absent and the vegetation was dominated by water loving plants like *Mentha longifolia* and *Nasturtium officinale*. The base height at the narrowest portion of the pass was about 848 m. The north facing mountain had a peak height of 1350 m and the south facing mountain had a normal height of 1650 m. Some peaks like Bakarai Sar and Puto Sar or Gishar Sar of the south facing mountain, however, reached 1710 m and 1905 m respectively. The south facing mountain presented a very large and

highly exposed area. At about 1200 m elevation the surface flattened up into a shallow plateau where soil, eroded from the surrounding rims had accumulated to form a cultivable land. Four or five perennial springs originated from within the Pine zone surrounding the plateau which ultimately joined into quite a large water body. This water, after catering for cultivation needs of the area, finally fell down as thick sheets at two or three different locations on this aspect. The availability of both land and water were causative factors for the presence of two small hamlets namely, Tanoor and Tangu with a cumulative population of about a hundred inhabitants. Their main sources of living were small size cultivation, dairy farming, fuel wood extraction and other forest products. The slopes were generally steep except at few places where flat meadows served as pastures and resting places for cattle.

HISTORICAL BACKGROUND OF THE AREA

About 3000 B.C. the tract of Swat and Buner was known as Gandhara (Anonymous, 1972). In 326 B.C, Alexander the Great defeated Raja Arnas, the then ruler of the region and included it in his territory. Zardashtism and Budhism were the main religions. During Budhism Swat was called Udyana and was under Kushan Dynasty. Near about 1000 A.D. a brave general of Mehmood Ghaznavi, General Khushal Khan, converted many Dalazak Afghans to Muslims through his personal efforts. Dalazaks were defeated by Yousafzai Pathans in 1481 A.D. and were pushed to Hazara where they still live under the name of Swatis. Later Mughals, Sikhs, Britishers and even the neighbouring states of Dir and Amb carried out many invasions of the area but none could succeed to take roots permanently. Finally in 1836 Akhund Sahib Abdul Ghafoor gained sufficient influence and power after victory against the Sikhs. In 1917 Mian Gul Shahzada Abdul Wadood popularly known as Badshah Sahib was enthroned unanimously by the local people. He established his regime in Buner area after defeating the rulers of Amb in 1924.

Two years later the then British Government also recognized Badshah Sahib as the legitimate ruler of the state. However in 1949 Badshah Sahib, abdicated his throne in favour of his son Major General Mian Gul Abdul Haq Jehanzeb. He ruled the area till 1969 when the state was merged with Pakistan by a Presidential order and since then it is under the administrative control of N.W.F.P. Pakistan.

The area, as a whole, is inhabited by the Yousafzais, though other tribes like Afghans, Aba Khels and Gujars are also very common. Some nomad Gujars have also constructed their summer abodes in the hills migrating back to plains in winter while others have settled down there permanently and work as tenants on scattered patches of clearings used for cultivation (Qureshi, 1981). The main crops are wheat, maize, mustard, barley, pulses, rice, tobacco and sugar cane. Poppy was a very popular cash crop of the area but due to its despicable misuse throughout the world, the Government has launched a series of schemes to deter its cultivation and to completely destroy it through ground and aerial sprays. The population largely depends on forests and forest products for their living. Lumbering, fuel wood extraction and dairy products make the basis of their livelihood. The climate of the region is very suitable to support different species of fuel plants. Being private property, these mountains are leased out every year to contractors for fuel wood extraction and to Gujars for use as grazing area for their cattle (Mohammad, 1989).

Ambela Pass, the research site, gained importance from the 1863 battle fought between the Britishers and the disciples of Syed Ahmad Shah Shaheed of Bareilly in which a number of people, including sixteen British officers, were killed and many more injured (Anonymous, 1979)

GEOLOGY

The Ambela granitic complex is a middle to late Paleozoic batholith consisting of over-saturated (70%), saturated (20%), under-saturated (5%) and Basic (5%) rocks (Rafiq, 1987). The complex encompasses the southern part of Buner and northern extremities of Mardan District. In north it is bounded by a series of rocks, like green schists, phyllites, marbles, calcareous schists amphibolites, siliceous schist and granitic gneisses, covering much of lower Swat, Buner and Malakand Agency while its southern margin comprises, Chamla phyllites and quartzite and Swabi shales, quartzite and limestones (Martin *et al.*, 1962). The complex is considered to be a part of the Peshawar plain alkaline igneous complex (Kempe and Jan, 1970 & 1980; Ahmad and Ahmad, 1974). The Ambela rocks are divided into three major groups (Rafiq *et al.*, 1984; Rafiq and Jan, 1988 & 1989).

Group-I includes granites and alkali granite. These two are the most abundant rock types and constitute about 70 percent of the bed rock surface. These granites are predominantly composed of feldspar and quartz minerals with minor biotite, muscovite, ilmenite and other accessories.

Group-II includes quartzsyenites, feldspathoidal syenites and other related rocks. These rocks, covering nearly 20 percent of the rock exposures, are grayish in colour and characterized by feldspars, feldspathoids quartz with biotite, hornblende, ilmenite, sphene and other accessories. Some volcanic rocks are also present in the Ambela complex.

Group-III is restricted in occurrence and mostly intrude as dykes into the rocks of Group-I and II. These are mostly dolerite dykes and mineralogically constitute Ca-Na feldspars, hornblend, pyroxen epidote, biotite, some ore and many accessory minerals.

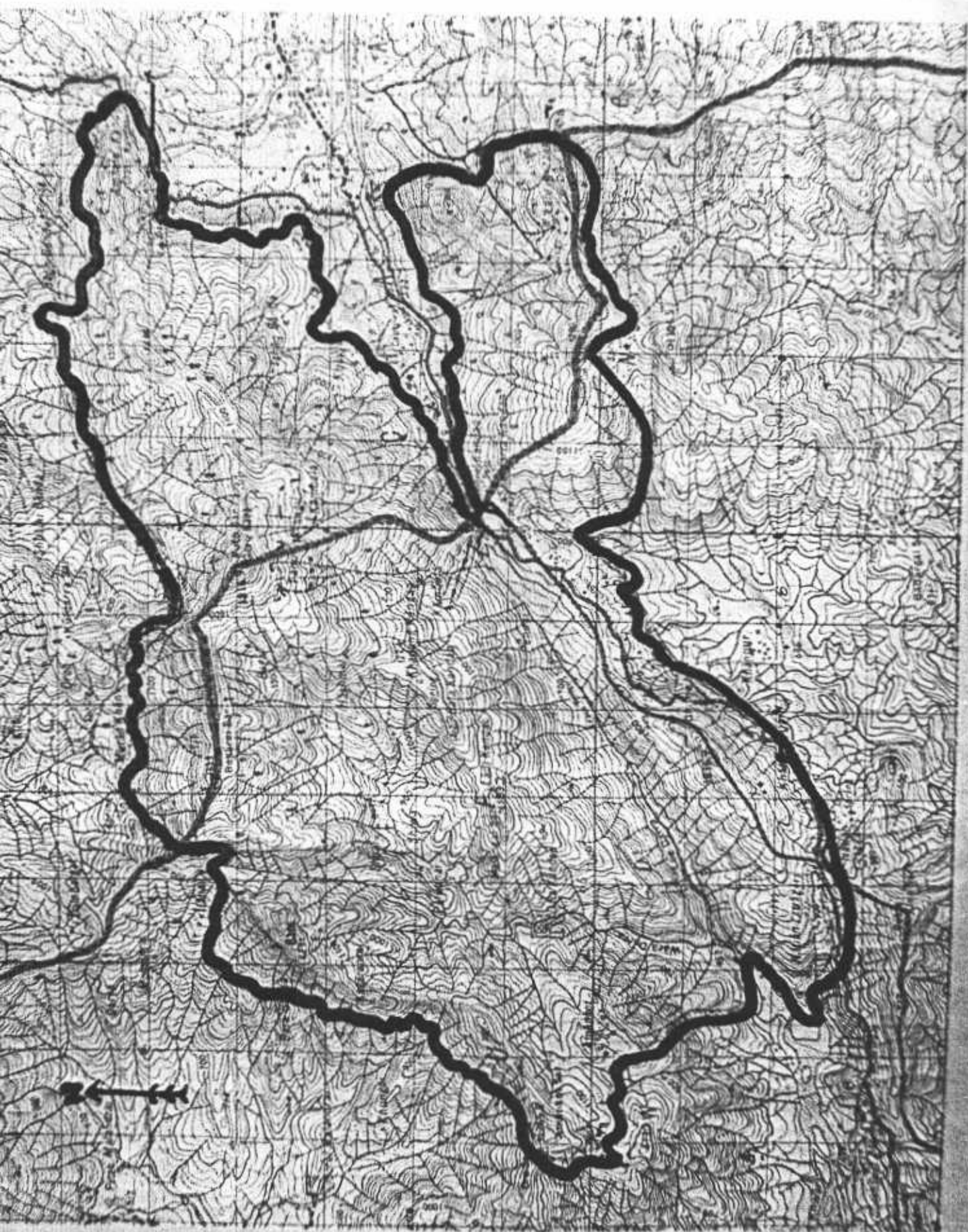
GEOMORPHOLOGY

Cartographic analysis indicates a zigzag ridge running from NW-SE which serves as a boundary between Swat and Mardan districts. The gradients, though varying greatly, are frequently steep. The highest peak in the site reaches 1905 m elevation. Other peaks with lesser elevation are also common (Fig. 1).

Fig. 1 Map of the area

Research site is cordoned off by black line.

scale 1 : 50,000



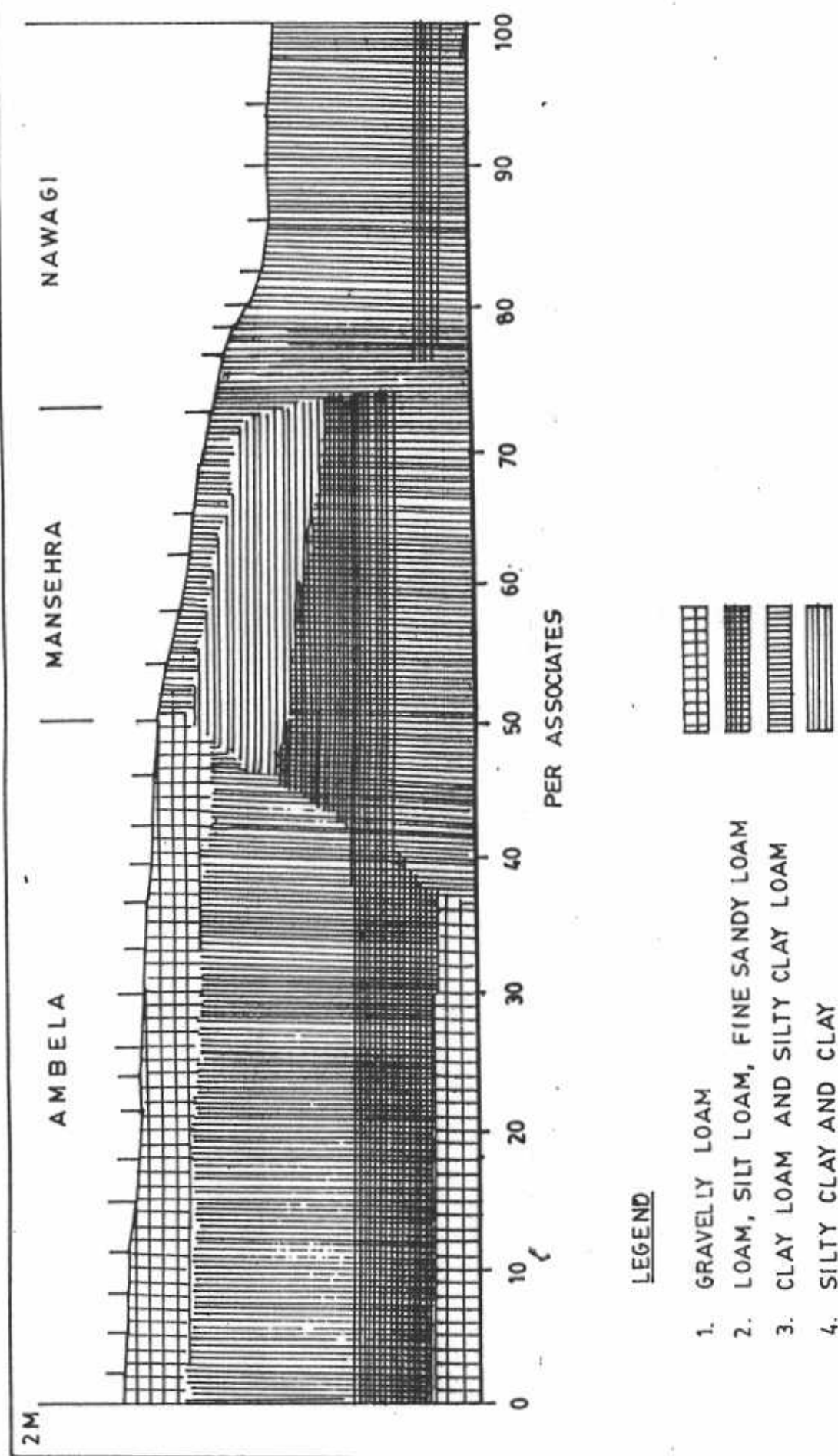
HYDROLOGY

Due to the absence of snow covered peaks there is no permanent water body flowing in the area. Tributaries arise from both the sides of the ridge which ultimately drain into Swat river on one side and Indus river on the other. Many springs originate here and there in the research area which merge to form a couple of small perennial nullahs flowing in an east west direction, ultimately discharging their water in Kabul River beyond Nowshera. These streams support their own characteristic flora.

SOILS

The soils of the area are classified as 'Ambela series' (Anonymous, 1975). They are deep, well drained, gravelly loam and non-calcareous soils.

The surface horizon is dark brown, gravelly loam massive and non-calcareous and is underlain by very dark grayish brown, dark brown and brown gravelly loam, clay loam and loam massive and non calcareous horizon (Fig. 2). The horizon boundaries are clear, irregular and abrupt. The Ab horizon ranges from 12 cm to 18 cm in thickness, is dark brown to brown in colour and from gravelly loam to clay loam in texture with very fine gravel. The structure is massive and non calcareous. The series is of limited extent and is distributed in a scattered way. It is associated with Nawagai and Mansehra series.



LEGEND

1. GRAVELLY LOAM
2. LOAM, SILT LOAM, FINE SANDY LOAM
3. CLAY LOAM AND SILTY CLAY LOAM
4. SILTY CLAY AND CLAY

Fig:2 Schematic Cross-Section Ambela Association.

CLIMATE

The area is characterized by a dry sub-tropical climate (Champion *et al.*, 1965). The climate is sub tropical sub humid. The summers are hot and dry with maximum temperature rising upto 40°C while the winters are cold with a mean minimum and mean maximum temperatures being 0.8°C and 38.0°C respectively (Table 1). The annual rain-fall, according to the nearest observatory located at Chakdara, is about 582.5 mm. The rains start in December, begin to increase in January/February and the maximum is reached in March/April. These decrease abruptly in the months of May and June when again the monsoon hits the area in July/August and heavy torrential rains occur till September. Again a rapid decline occurs in October and November each year.

About 2/3rd of the total annual rainfall is received from December to April. These cold period precipitations are extremely important for the vegetation as they are soft, steady and regular and get directly absorbed in the soil. The summer rains, on the other hand, are heavy and torrential damaging soil through erosion (Beg and Khan, 1974). High peaks like Bakro Sar, Bata Sar and Patu Sar receive snow fall in the coldest months. The snowfall may occasionally reach as low as Tanoor and Tangu villages but the snow melts away quickly.

Table-1 The averages of the climatic data for the last 10 years (1979-1988) collected at the nearest Meteorological Station at Chakdara.

Month	TEMPERATURE				RAINFALL	HUMIDITY AT	
	Mean Max. C°	daily Min. C°	Extremes Max. C°	Min. C°	Mean total mm	800 hrs.	1700 hrs.
January	14.7	0.8	20.6	10.0	66.0	84	58
February	17.5	2.5	23.9	-13.9	81.5	76	46
March	21.8	9.4	30.6	-4.0	115.6	74	48
April	28.8	13.8	33.0	0.0	59.7	60	36
May	35.1	19.4	38.1	3.9	13.0	48	30
June	38.0	21.7	41.5	8.3	7.1	43	25
July	36.1	23.8	37.7	11.1	80.3	62	45
August	34.1	23.2	37.4	7.9	87.9	77	59
September	33.8	20.1	33.9	3.3	35.3	73	52
October	30.2	13.8	32.2	0.1	12.2	64	39
November	23.6	7.7	28.0	-7.2	5.1	65	47
December	17.3	3.6	22.4	-9.4	18.8	77	52
Annual values	331.0	159.8	379.3	-9.9	582.5	803	537
Mean Monthly values	27.58	13.32	31.61	-0.83	48.54	66.92	44.75

Source: Pakistan Meteorological Department, Lahore.

REVIEW OF LITERATURE

A large and voluminous data is available on the phytosociological studies of different areas and climatic locations in Pakistan. Repp (1962) gave a quantitative description of the vegetation belonging to Sind and certain areas of Punjab. He also suggested ways of land use for different locations. Qadir *et al.* (1966) recognized six different and distinct plant communities during a survey of the flora of Karachi University campus and correlated them with edaphic factors. Chaudhri and Chuttar (1966) described the Thar desert vegetation and discussed the relationship of the communities. The vegetation of Nagar Parkar was described and categorized into formations which were then correlated with characteristic soil conditions by S.M. Hussain (1964). H. Hussain (1970) studied the coastal dunes ecology in Karachi and its neighbourhood. While Karim (1970) was busy in developing an objective classification of the plant communities of the coastal swamps of Karachi, Shaukat and Qadir (1971) worked on the vegetation of the calcareous hills around Karachi. Shaukat and Hussain (1972) analyzed the stream vegetation of Karachi and Khadiji fall area. Shaukat *et al.* (1976) gave a detailed report on the phytosociology of Gadap area, southern Sind. Ahmad *et al.* (1978) analyzed the vegetation of Gharo, Dhabeji and Manghopir industrial area. They also carried out physical and chemical analysis of the soil and constructed a 3-dimensional ordination on the basis of integral response to various soil factors. In the same year Shaukat *et al.* (1978) analyzed the vegetation around Gadap, a small village in Sind, to work out a relationship between dominance, diversity and community maturity index. Again in 1981, Shaukat *et al.* published a report on the vegetational dynamics of calcareous hills around Karachi. The structure, composition and pattern of a ruderal vegetation in Karachi was studied by Khan *et al.* (1987).

In Baluchistan plant sociologists were busy in describing the vegetation of the province and worked on its different parameters. Kayani *et al.* (1984) worked on the relationship between plant communities of soil and the physico-chemical nature of wastelands of Quetta Pishin districts. Changezi (1982) discussed the relationship of the soil with the vegetation of the wastelands around Quetta. Tareen and Qadir (1987) grouped 16 plant communities into 4 steppe types on the basis of index of similarity which were then correlated with the edaphic factors. They found that protected areas and vegetation of graveyards showed high coverage and species diversity than the unprotected ones. Kayani *et al.* (1984) and Kayani *et al.* (1984 b) studied the effect of protection on the composition of vegetation and the relationship of plant cover with soil salinity respectively. In yet another article Kayani *et al.* (1988) correlated 9 plant communities with fine to coarse textured and moderate to thoroughly calcareous soils. Among the earlier workers Khan and Hussain (1963) studied the effect of closure in a forest in Hazarganji, Quetta, while Beg (1966) gave a preliminary description of the vegetation of Quetta.

In order to ascertain the course a vegetation would take, if left to itself, Chaghtai and his colleagues in NWFP, chose graveyards vegetation for their studies. These are comparatively protected from biotic interferences being held with awe, sanctity and sacredness by the Muslims in the Indo-Pak subcontinent.

Chaghtai and Yousaf (1976) worked on the ecology of the native vegetation of Kohat; Chaghtai and Shah (1977) worked on the relationship between species diversity and the structural and edaphic characteristics of the communities. Chaghtai *et al.* (1978) carried out a phytosociological study of the graveyards of Peshawar district. Chaghtai and Shah (1978) determined the coefficient of community for the plant communities of the graveyards of Peshawar district. Similarly the vegetation of graveyards of Kohat division, vegetation around a shrine in Nilab valley, NWFP and the ecology of an upland forest near Nowshera NWFP were also studied

by Chaghtai and his colleagues (Chaghtai *et al.* 1983; 1984 & 1988). Beside, this Chaghtai and Ghawas (1976) studied the effect of exposure on community set up in Malakand Pass, NWFP; Malook and Naqvi (1982) gave a brief resume of the phytosociology of the famous Karamar Hill of Adina village, district Swabi, Mardan, NWFP. Chaghtai and Khattak (1983) worked on the ecology of a dry stream bed in Peshawar. A year later the same authors published their observations on the ecology of the grass lawns in Peshawar (Chaghtai and Khattak, 1984); Chaghtai *et al.* (1985) studied the successional trends in an abandoned field in Peshawar. Ahmad (1986) published his article on the vegetation of some Himalayan foot hills; Hussain and Shah (1989) worked on the vanishing sub tropical vegetation of Swat, while Hussain and Khan (1989) described some hydrophytic communities along a stream in Swabi district, NWFP.

This is the first detailed study of the area and no such work has been carried out here earlier.

MATERIALS AND METHODS

The vegetation of the area was sampled using the line transect and quadrat method. Arboreal vegetation measuring 5 cm CBH (Circumference at Breast Height) and above was sampled in 10 x 4 m quadrats while for herbaceous ground flora 0.25 x 0.5 m quadrat was used. These quadrats were laid down systematically in sites randomly selected on the basis of general appearance. The information on community parameters, such as density, frequency and canopy coverage was collected and their relative values were calculated to determine the importance values of different species according to the method described by Cox (1967). For the estimation of canopy coverage values Daubenmire's technique (1959) was adopted. The communities have been named on the basis of dominant members having highest importance value one each from tree, shrub and herb layers. Dominance of community was ascertained by Simpson's Index (1949)

$$D = \sum_{i=1}^s \left(\frac{ni}{N} \right)^2$$

$$\text{where } \left(\frac{ni}{N} \right)^2 = (Pi)^2$$

= the proportion of the individuals belonging to the *i*th species to the total number of individuals in the sample.

General diversity was determined using Shannon-Wiener information function

$$H = \sum_{i=1}^s (Pi) (\log_2 Pi) \quad (\text{Margalef, 1957})$$

The general diversity incorporates two components (LLoyd and Ghelardi, 1964)

(a) Equitability, which expresses the evenness of allotment of individual species. This was determined using Pielou Index (1976) which is expressed as

$$e = H/H_{\max}$$

Where e = equitability, H is observed general diversity and $H_{\max}$ is maximum diversity and is denoted by $\log_2 S$, where S is the total number of species in a community.

(b) Species richness which is the number of different species present in a community. This is denoted by the equation proposed by Menhinick (1964) as

$$d = \frac{S}{\sqrt{N}}$$

Where d = species richness, S = total number of species and N = total number of individuals of all species.

Community maturity index was calculated by the formula suggested by Pichi-Sermoli (1948). It works on the principle that the lesser the number of sporadic species and the greater the frequency percent of each species, the more mature is the community.

The formula is expressed as

$$C.M. = \frac{\sum_{i=1}^S F_3}{S}$$

Where C.M. is community maturity, F_3 is the percentage frequency of a species and S is the total number of species in a community.

Coefficient of community was determined using formula employed by Motyka *et al.* (1950) and Culberson (1955) which is expressed as

$$CC = \frac{2W}{a+b} \times 100$$

Where C C is coefficient of community, W is the lowest value of the pair of percentages of the species common to both stands and a and b are the number of species of the two stands to be compared.

Computer was used for the analysis of data and the construction of graphs and histograms.

Physical and chemical analysis of soil was done according to methods described in U.S.D.A. Handbook No. 60 (Anonymous, 1954) and the nomenclature of plants followed is that of Stewart (1958, 1967 & 1972), Parker (1956) and Cope (1982).

Properly preserved specimens have been deposited in the herbarium of the Department of Botany, Islamia College, University of Peshawar, NWFP, Pakistan.

RESULTS AND DISCUSSION

A total of 49 stands (24 in spring and 25 in the fall seasons) were sampled. On the basis of similarity they were grouped in 14 spring and 14 fall communities. Out of each of these 14 communities, 2 were pertaining to the stream vegetation, 9 occupied the different slopes of the North-,South-and East-facing aspects (Tables 2 & 3) while the remaining 3 communities were related to the meadows. These last 3 could not be shown in the tables.

Sampling revealed a clear difference both qualitative and quantitative, between the spring and fall vegetation as is clear from the facts that only 2/3 rd of the total number of spring plants were present in the fall season and most of them were different species; an obvious manifestation of the different sets of environments prevailing in the two seasons [Tables 4, 5, 6 & 7].

It was this idea in mind that the communities of the same aspect and elevation but of the two different seasons have been described and discussed one after the other to facilitate comparison.

Table 2 Plant communities and their elevations on different aspects of ambela pass

ELEV	S P R I N G F L O R A			F A L L F L O R A			ELEV
	N.F	S.F	E.F	N.F	S.F	E.F	
1905							1905
1850		P.B.G	P.B.G		P.B.O	P.B.O	1850
1750			[1560 -		[1625-		1750
1650		[1540-	1905m]		1905]	[1550-	1650
1560		1905m]				1905m]	1625
1550							1610
1540					P.D.M		1550
1535		P.D.R	P.D.O				1530
1450		[1305-			[1340-	P.D.O	1450
1350		1535m]	[1180-		1610]		1350
1305			1550m]			[1150-	1340
1250	P.D.M			P.D.S		1530m]	1300
1180		M.D.T			M.D.O		1250
1160	[880 -			[800-	[1060-		1150
1150	1350m]	[1040-		1350m]	1399m]		1100
1050		1250m]	M.D.T				1060
1040						M.D.A	1050
990			[725-				1000
950		D.J.T	1160m]			[720-	650
880					M.H.O	1100m]	850
850		[550-					800
840		990m]			[565-		785
750	M.D.T			M.D.P	785m]		750
725	[540 -						720
650	840m]			[565-			650
550				785m]			600
540							565
							550
							540

LEGENDS:

N.F = North facing

S.F = South facing

E.F = East facing

P.D.M = *Pinus Dodonaea Micromeria*P.B.G = *Pinus Berberis Geranium*P.D.R = *Pinus Dodonaea Rumex*P.D.O = *Pinus Dodonaea Oxalis*P.D.S = *Pinus Dodonaea Setaria*P.B.O = *Pinus Berberis Oxalis*P.D.M = *Pinus Dodonaea Micromeria*M.D.T = *Mallotus Dodonaea Themeda*M.D.P = *Mallotus Dodonaea Poa*M.D.O = *Mallotus Dodonaea Oxalis*M.H.O = *Mallotus Helicteres Oxalis*M.D.A = *Mallotus Dodonaea Aristida*D.J.T = *Dodonaea Justicia Themeda*

Table 3 Stream vegetation

S P R I N G F L O R A		F A L L F L O R A	
ARUNDO-MENTHA COMMUNITY (ELEV. 550-680m)	MENTHA- NASTURTIIUM COMMUNITY (ELEV. 690-825m)	ARUNDO- NASTURTIIUM COMMUNITY (ELEV. 550-680m)	MENTHA NASTURTIIUM-MENTHA COMMUNITY (ELEV. 690-825)

Table 4 Total number of species recorded in the research area in spring season

Aspect	Herbaceous species	Woody species	Total species
North Facing	52 (56.5)	15 (46.9)	67 (54.0)
South Facing	64 (69.6)	25 (78.1)	89 (71.8)
East Facing	56 (60.9)	17 (53.1)	73 (58.9)

Figures in parenthesis represent percent value of each.

Table 5 Spring flora of the research area and its structural characteristics

(R.D.: Relative density; R.F.: Relative frequency; R.C.C.: Relative canopy cover and I.V.: Importance value)

Name of species	North Facing				South Facing				East Facing			
	R.D.	R.F.	R.C. C.	I.V.	R.D.	R.F.	R.C. C.	I.V.	R.D.	R.F.	R.C.C.	I.V.
<u>Herbaceous species</u>												
<i>Achyranthus aspera</i> L.	0.07	0.22	0.04	0.3	-	-	-	-	0.6	1.7	0.1	2
<i>Adiantum incisum</i> Forsk.	7.05	4.28	1.44	13	12.38	6.75	4.43	24	11.7	9.0	5.0	26
<i>Ajuga bracteosa</i> Wall. ex Bth.	0.33	0.98	0.17	2	2.06	3.14	1.52	7	3.8	9.1	3.3	16
<i>Allium rubellum</i> M.Bieb.	0.1	0.32	0.05	1	-	-	-	-	-	-	-	-
<i>Amaranthus graecizans</i> L.	-	-	-	-	1.62	2.15	0.81	4	0.6	1.7	0.1	2
<i>Anagallis arvensis</i> L.	4.53	3.81	1.67	10	18.49	9.88	6.29	35	6.7	8.0	2.0	17
<i>Alpaca multica</i> var. <i>aristata</i> Hack. et Baker.	-	-	-	-	-	-	-	-	1.2	2.0	0.7	4
<i>Arenaria serpyllifolia</i> L.	7.88	5.36	3.12	16	6.2	5.41	2.57	14	3.0	2.6	1.5	7
<i>Aristida adscensionis</i> L.	3.08	7.75	7.38	18	10.62	5.76	11.11	28	6.7	16.6	24.1	47
<i>A. cyanantha</i> Nees ex Steud.	-	-	-	-	-	-	-	-	3.8	11.1	18.9	34
<i>Artemisia scoparia</i> Waldst and Kit	0.2	0.63	0.18	1	-	-	-	-	0.4	1.0	0.3	2
<i>Asplenium trichomanes</i> L.	3.13	2.21	0.62	6	12.9	7.4	3.51	24	3.7	3.7	2.4	10
<i>Boerhaavia coccinea</i> Mill.	-	-	-	-	0.28	0.82	0.22	1	0.06	0.2	0.02	0.3
<i>Breua arvensis</i> (L.) Less	0.02	0.06	0.08	0.2	-	-	-	-	-	-	-	-
<i>Bromus japonicus</i> Thunb.	2.09	2.39	0.79	5	0.28	0.26	0.05	1	-	-	-	-
<i>Calendula arvensis</i> L.	0.86	1.89	0.86	4	0.17	0.26	0.05	1	-	-	-	-
<i>Campanula benthamii</i> Wall.	-	-	-	-	-	-	-	-	1.4	2.6	0.7	5
<i>Cannabis sativa</i> L.	1.0	1.68	0.63	3	14.94	17.46	7.27	32	10.9	10.3	5.0	26
<i>Cerastium dichotomum</i> L.	-	-	-	-	-	-	-	-	1.0	1.6	0.4	3
<i>Cheilanthes pteridioides</i> C. Chr	-	-	-	-	0.4	0.01	0.2	1	0.2	0.5	0.1	1
<i>Chenopodium album</i> L.	0.06	0.16	0.04	0.3	0.15	0.34	0.06	1	-	-	-	-
<i>Coryza bonariensis</i> Cronquist.	1.1	2.96	0.96	5	3.81	6.08	1.08	11	2.7	7.7	2.5	13
<i>Corbichonia decumbens</i> Exell.	-	-	-	-	0.28	0.41	0.08	1	0.8	1.3	0.07	2
<i>Coronopus didymus</i> Sm.	-	-	-	-	0.19	0.34	0.04	1	-	-	-	-
<i>Crotalaria medicaginea</i> Lam.	-	-	-	-	0.15	0.34	0.06	1	-	-	-	-
<i>Cymbopogon schoenanthus</i> Spreng	2.71	5.4	12.4	21	4.17	6.23	3.08	14	0.6	1.5	2.0	4
<i>Cynodon dactylon</i> Pers	0.5	0.86	0.96	1	10.22	9.22	13.22	33	6.7	7.3	4.7	18
<i>Cyperus niveus</i> Retz.	0.53	0.62	0.1	1	12.93	10.09	2.94	26	-	-	-	-

Table 5 (contd)

<i>Delphinium kotatense</i> Munz.	-	-	-	-	0.1	0.3	0.1	1	-	-	-	-
<i>Dicliptera roxburghiana</i> Nees	2.86	6.24	2.73	12	6.34	10.51	4.97	22	1.8	2.6	1.5	6
<i>Eragrostis pilosa</i> Beauv.	0.49	0.9	1.1	3	-	-	-	-	-	-	-	-
<i>Erigeron alpinus</i> L.	-	-	-	-	0.2	0.6	0.2	1	0.2	0.5	0.1	1
<i>Erodium cicutarium</i> L'Herit.	10.24	9.98	6.56	27	3.7	4.8	1.7	10	1.7	4.5	1.5	8
<i>Evolvulus alsinoides</i> L.	-	-	-	-	0.2	0.7	0.09	1	-	-	-	-
<i>Filago pyramidata</i> L.	-	-	-	-	2.6	0.6	1.3	5	-	-	-	-
<i>Gagea elegans</i> Wall. ex Royle	0.99	1.3	0.35	3	-	-	-	-	-	-	-	-
<i>Gallium aparine</i> L. Beauv.	6.67	11.9	1.9	21	12.9	10.07	4.3	27	13.1	4.2	5.0	22
<i>Gerbera gossypina</i> Beauv.	-	-	-	-	0.8	2.4	0.7	4	-	-	-	-
<i>Geranium ocellatum</i> Camb.	5.75	6.3	3.8	16	19.65	20.77	21.59	62	17.3	23.9	13.2	54
<i>Gnaphalium affine</i> D.Don.	34.39	17.62	12.38	64	44.32	18.42	6.1	69	10.7	13.4	3.8	28
<i>Heliotropium europaeum</i> L.	0.14	0.44	0.08	1	-	-	-	-	-	-	-	-
<i>Hemaria hirsuta</i> L.	-	-	-	-	-	-	-	-	1.0	2.0	0.8	4
<i>Heteropogon contortus</i> P.Beauv.	-	-	-	-	-	-	-	-	6.9	4.2	5.8	17
<i>Imperata cylindrica</i> Racuschel.	-	-	-	-	1.2	1.6	0.22	3	-	-	-	-
<i>Innula cappa</i> DC.	0.14	0.23	0.05	1	0.17	0.13	0.03	0.3	2.3	4.2	0.8	7
<i>Kichcia ramosissima</i> Janchen.	-	-	-	-	0.45	0.95	0.42	2	-	-	-	-
<i>Kochia indica</i> Wight	-	-	-	-	-	-	-	-	0.06	0.2	0.02	0.3
<i>Koeleria gracilis</i> Pers.	3.83	2.84	1.41	8	0.99	1.03	0.58	3	0.5	1.3	0.1	2
<i>Lactuca dissecta</i> D.Don	2.24	4.0	0.8	8	3.31	0.75	1.14	7	-	-	-	-
<i>Lathyrus erectus</i> Lagisca.	1.0	1.58	0.7	3	-	-	-	-	-	-	-	-
<i>Lespedeza floribunda</i> Bunge.	-	-	-	-	0.17	0.26	0.05	1	-	-	-	-
<i>Medicago orbicularis</i> Bart.	0.24	0.46	0.15	1	0.4	0.3	0.1	1	0.4	1.0	0.3	2
<i>Micromeria biflora</i> Bth.	36.1	15.3	6.12	58	37.5	16.33	9.9	64	12.0	15.2	0.1	35
<i>Oenothera rosea</i> Soland.	-	-	-	-	14.0	10.9	7.2	32	-	-	-	-
<i>Oxalis corniculata</i> L.	28.85	20.9	4.56	54	58.8	31.42	19.6	1.7	60.4	31.1	2.5	115
<i>Phularis minor</i> Retz.	0.29	0.4	0.07	1	6.1	3.6	1.7	11	-	-	-	-
<i>Physalis minima</i> L.	-	-	-	-	2.6	0.6	1.3	4	-	-	-	-
<i>Plantago lanceolata</i> L.	-	-	-	-	1.5	1.2	0.3	3	-	-	-	-
<i>Poa infirma</i> H.B.K.	5.43	5.46	2.35	13	-	-	-	-	0.2	0.5	0.1	1
<i>Polygala abyssinica</i> R.Br.	-	-	-	-	0.15	0.34	0.06	1	-	-	-	-
<i>Polygonum paronychioides</i> C.A. Mey ex Hohen.	0.1	0.1	0.07	0.3	0.54	0.26	0.13	1	-	-	-	-

Table 5 (contd)

<i>Polypogon monspeliensis</i> (L.) Desf.	-	-	-	-	-	-	-	-	0.2	0.5	0.7	1
<i>Portulaca oleraceae</i> L.	-	-	-	-	0.37	0.41	0.08	1	-	-	-	-
<i>Potentilla supina</i> L.	-	-	-	-	-	-	-	-	1.8	1.6	1.1	5
<i>Rumex hastatus</i> D. Don.	0.12	0.26	0.59	1	7.8	11.5	17.1	36	0.5	1.0	2.7	4
<i>Scirpus mucronatus</i> L.	0.04	0.1	0.03	0.2	-	-	-	-	2.3	0.5	0.8	6
<i>Setaria pumila</i> Roem & Schult	0.24	0.16	0.04	0.4	-	-	-	-	3.9	0.5	2.0	6
<i>Sida cordata</i> Bours	-	-	-	-	4.08	3.43	1.22	9	0.06	0.2	0.02	0.3
<i>Silene arinosa</i> C. Koch	0.02	0.06	0.01	0.1	0.09	0.13	0.03	0.3	-	-	-	-
<i>Sisymbrium irio</i> L.	-	-	-	-	-	-	-	-	0.2	0.5	0.1	1
<i>Sonchus asper</i> (L.) Hill.	0.15	0.56	0.11	1	-	-	-	-	-	-	-	-
<i>Sicliaria media</i> Cyr	-	-	-	-	0.06	0.14	0.02	0.2	-	-	-	-
<i>Stipa capensis</i> Thunb.	0.3	0.46	0.07	1	5.84	9.29	6.29	21	2.6	1.6	2.3	7
<i>Taraxacum officinale</i> Weber	0.12	0.38	0.06	1	0.19	0.69	0.09	1	0.2	0.5	0.1	1
<i>Themeda anathera</i> Hack	12.87	25.91	59.11	98	35.83	31.80	71.61	139	17.1	19.6	34.6	71
<i>Torilis leptophylla</i> (L.) Reichb.	0.58	1.26	0.29	2	0.77	0.86	0.25	2	-	-	-	-
<i>Tribulus terrestris</i> L.	-	-	-	-	-	-	-	-	0.5	1.7	0.1	2
<i>Trigonella incisa</i> Bth.	-	-	-	-	-	-	-	-	0.4	1.0	0.3	2
<i>Verbascum thapsus</i> L.	-	-	-	-	0.2	0.6	0.2	1	0.2	0.5	0.1	1
<i>Veronica arvensis</i> L.	-	-	-	-	2.39	2.74	1.34	7	-	-	-	-
<i>Vicia monantha</i> Retz.	-	-	-	-	0.69	1.33	0.45	3	2.3	2.6	1.3	6
<i>Viola canescens</i> Wall. ex Roxb.	3.43	3.31	0.89	8	2.3	4.8	2.0	9	2.9	9.6	3.2	17
<i>Zornia gibbosa</i> Span.	-	-	-	-	0.06	0.16	0.03	0.3	-	-	-	-
Woody species												
<i>Abutilon bidentatum</i> (L.) Sweet.	-	-	-	-	0.67	0.69	0.21	2	-	-	-	-
<i>Acacia modesta</i> Wall.	0.5	6.7	0.3	8	8.7	18.72	10.83	38	-	-	-	-
<i>Ailanthus altissima</i> Swingle	0.29	0.7	0.16	1	-	-	-	-	-	-	-	-
<i>Asparagus gracilis</i> Royle	0.02	0.06	0.08	0.2	-	-	-	-	-	-	-	-
<i>Barleria cristata</i> L.	-	-	-	-	-	-	-	-	0.2	0.5	0.1	1
<i>Berberis lycium</i> Royle	8.3	14.0	11.1	33	20.4	26.0	2.4	49	9.8	13.3	13.24	36
<i>Buddleja crispa</i> Bth.	-	-	-	-	0.15	0.34	0.04	1	-	-	-	-
<i>Butea monosperma</i> Roxb.	-	-	-	-	-	-	-	-	0.9	2.5	0.8	4
<i>Curisia opaca</i> Stapf.	0.49	0.7	0.01	1	1.88	5.74	2.15	10	0.3	0.9	0.01	1
<i>Cassia fistula</i> L.	-	-	-	-	1.21	5.04	15.03	21	-	-	-	-
<i>Celtis australis</i> L.	-	-	-	-	1.1	4.4	0.2	6	-	-	-	-

Table 5 (contd)

<i>Clematis graveolens</i> Lindl.	-	-	-	-	4.5	7.8	0.2	13	1.6	3.7	1.1	6
<i>Colebrookea oppositifolia</i> Sm.	0.02	0.06	0.19	0.3	-	-	-	-	-	-	-	-
<i>Cotoneaster nummularia</i> Fisch. and Mey.	-	-	-	-	-	-	-	-	0.2	0.5	0.2	1
<i>Debregeasia salicifolia</i> Rendle.	2.47	21.84	2.7	27	7.99	7.59	5.4	22	0.3	0.9	0.01	1
<i>Desmodium motorium</i> Merrill.	0.17	0.3	0.12	1	-	-	-	-	-	-	-	-
<i>Dodonaea viscosa</i> L.	42.99	61.88	73.79	179	60.79	61.32	85.7	208	29.4	33.5 1	34.03	97
<i>Ficus palmata</i> Forssk.	-	-	-	-	2.6	0.6	1.3	5	-	-	-	-
<i>Flacourtia indica</i> Merrill.	-	-	-	-	1.2	2.2	1.7	5	-	-	-	-
<i>Grewia optiva</i> Drum.	-	-	-	-	3.89	4.93	4.23	13	0.2	0.4	0.8	1
<i>Helicteres isora</i> L.	-	-	-	-	1.26	2.34	0.87	5	-	-	-	-
<i>Indigofera heterantha</i> Wall.	1.0	2.7	8.05	12	8.41	11.09	3.07	23	13.4	13.7	5.3	32
<i>Justicia adhatoda</i> L.	0.81	6.42	5.41	13	30.7	29.5	31.1	91	8.0	11.3	20.6	40
<i>Mallotus philippensis</i> Muell.	39.42	59.93	54.42	154	29.35	45.94	49.17	125	17.9	10.3	3.03	39
<i>Maytenus royleana</i> Cufodontia.	-	-	-	-	0.78	5.60	1.26	8	2.5	3	0.1	9
<i>Minosa himalayana</i> Gamble.	0.2	4.1	0.2	5	-	-	-	-	-	-	-	-
<i>Myrsine africana</i> L.	0.2	5.8	0.3	6	-	-	-	-	-	-	-	-
<i>Olea ferruginea</i> Royle	-	-	-	-	2.4	4.1	2.4	9	3.8	8.0	0.2	12
<i>Otostegia limbata</i> Boiss.	0.24	0.48	0.61	1	-	-	-	-	-	-	-	-
<i>Phoenix humilis</i> L.	-	-	-	-	0.1	0.3	1.6	2	-	-	-	-
<i>Pinus roxburghii</i> Sargent.	17.1	24.4	97.3	139	86.3	65.4	89.4	241	91.1	89.7	98.1	279
<i>Plectranthus rugosus</i> Wall.	0.05	0.16	0.02	0.2	1.19	3.13	3.23	8	3.0	5.2	14.1	22
<i>Rhamnus triquetra</i> Wall.	-	-	-	-	0.39	1.1	0.002	1	-	-	-	-
<i>Rubus ellipticus</i> Smith.	0.1	0.32	0.61	1	6.4	9.7	0.12	16	1.2	0.1	11.5	16
<i>R. niveus</i> Hk.F.	-	-	-	-	-	-	-	-	0.1	1.0	2.1	3
<i>Sageretia thea</i> var. <i>brandrethiana</i> Brongn.	0.49	1.8	0.03	2	13.5	26.32	20.11	60	5.2	13.5	6.05	25
<i>Syzygium cumini</i> var. <i>caryophyllifolia</i> R.R.S.	-	-	-	-	0.6	1.1	0.16	2	-	-	-	-
<i>Tylophora hirsuta</i> Wight.	0.20	0.82	0.21	1	0.99	1.63	0.64	3	0.26	0.7	0.42	1
<i>Xanthium strumarium</i> L.	-	-	-	-	0.15	0.34	0.06	1	1.1	1.7	1.9	5
<i>Zanthoxylum alatum</i> Roxb.	0.97	1.8	0.2	3	-	-	-	-	-	-	-	-
<i>Zizyphus nummularia</i> Wight.	-	-	-	-	0.29	1.1	0.06	2	-	-	-	-
<i>Zizyphus oxyphylla</i> Edgew.	-	-	-	-	-	-	-	-	0.2	0.4	0.3	1

Table 6 Total number of species recorded in the research area in fall season

Aspect	Herbaceous species	Woody species	Total species
North Facing	38 (64.4)	14 (63.6)	52 (64.2)
South Facing	29 (49.2)	18 (81.8)	47 (58.0)
East Facing	26 (44.1)	12 (54.5)	38 (46.9)

Figures in parenthesis represent percent value of each.

Table 7 Fall flora of the research area and its structural characteristics

D.: Relative density; R.F.: Relative frequency; R.C.C.: Relative canopy cover and I.V.: Importance value)

Name of species	North Facing				South Facing				East Facing			
	R.D.	R.F.	R.C. C.	I.V.	R.D.	R.F.	R.C. C.	I.V.	R.D.	R.F.	R.C. C.	I.V.
Herbaceous species												
<i>Achyranthus aspera</i> L.	-	-	-	-	-	-	-	-	2.7	3.2	0.9	7
<i>Adiantum incisum</i> Forssk.	21.8	8.16	6.1	36	26.78	10.5	2.14	39	23.34	13.03	4.96	41
<i>Ajuga bracteosa</i> Wall. ex Bth.	-	-	-	-	3.55	5.39	2.26	11.2	2.56	5.19	1.72	10
<i>Amaranthus viridis</i> L.	0.2	0.2	0.01	0.4	-	-	-	-	-	-	-	-
<i>Androsace rotundifolia</i> Hardw.	-	-	-	-	0.12	0.29	0.03	0.4	-	-	-	-
<i>Alpida mutica</i> (L.) Hack.	-	-	-	-	7.37	13.68	4.04	25	6.06	10.99	8.99	26
<i>Arctostaphylos uva-ursi</i> L.	34.8	32.9	31.2	99	17.19	26.5	9.91	53	16.7	25.04	52.81	95
<i>Asplenium trichomanes</i> L.	-	-	-	-	3.0	3.0	2.0	8	-	-	-	-
<i>Bergenia himalaica</i> Boriss.	-	-	-	-	1.0	2.0	13.0	16	-	-	-	-
<i>Bibens chinensis</i> Willd.	0.2	0.6	0.1	1	-	-	-	-	6.0	10.17	3.05	19
<i>Boerhaavia coccinea</i> Mill.	-	-	-	-	-	-	-	-	0.9	1.0	0.1	2
<i>Cannabis sativa</i> L.	0.06	0.2	0.04	0.3	14.28	25.856	19.95	60	7.76	11.29	3.18	22
<i>Cenchrus ciliaris</i> L.	1.1	0.8	0.3	2	-	-	-	-	-	-	-	-
<i>Ceterach dalhousiae</i> C.Chr	5.8	5.0	1.2	12	13.0	11.0	7.0	31	23.2	13.47	4.74	41
<i>Cheilanthes pteridoides</i> C.Chr	4.2	6.3	5.3	16	-	-	-	-	-	-	-	-
<i>Chenopodium album</i> L.	0.4	7.4	0.2	8	-	-	-	-	-	-	-	-
<i>Chrysopogon sarrulatus</i> Trin.	1.42	4.4	2.5	8	1.6	2.1	0.9	5	-	-	-	-
<i>Convolvulus arvensis</i> L.	0.03	0.12	0.02	0.2	-	-	-	-	-	-	-	-
<i>Conyza bonariensis</i> Cronquist.	2.6	4.4	1.3	8	12.37	88.87	2.49	34	17.96	16.98	2.87	38
<i>Crotalaria medicaginea</i> Lam.	0.08	0.22	0.01	0.3	-	-	-	-	-	-	-	-
<i>Cymbopogon schoenanthus</i> Spreng	-	-	-	-	2.32	6.0	12.24	21	-	-	-	-
<i>Cynodon dactylon</i> Pers	4.1	1.8	0.86	7	2.54	2.44	0.38	5	34.2	15.9	10.7	61
<i>Cyperus niveus</i> Retz.	9.1	15.5	17.0	42	8.37	3.799	0.44	13	-	-	-	-
<i>Dicliptera roxburghiana</i> Nees	0.06	0.2	0.2	1	14.14	48.411	5.55	48	-	-	-	-
<i>Eragrostis pilosa</i> Beauv.	0.23	0.4	0.07	1	-	-	-	-	1.5	2.6	1.2	5
<i>Erigeron alpinus</i> L.	0.55	1.4	0.22	2	-	-	-	-	2.6	1.9	2.4	7
<i>Euphorbia helioscopia</i> L.	0.03	0.12	0.02	0.2	-	-	-	-	-	-	-	-
<i>E. indica</i> Lam.	0.03	0.12	0.02	0.2	-	-	-	-	-	-	-	-

Table 7 (contd)

<i>L. pilulifera</i> var. <i>hirta</i> Thell.	-	-	-	-	-	-	-	-	0.4	0.6	0.3	1
<i>Gallium aparine</i> L. Beauv.	0.2	0.4	0.02	1	-	7	-	-	-	-	-	-
<i>Geranium ocellatum</i> Canb.	0.2	7.4	0.4	8	4.0	9.07	5.0	18	-	-	-	-
<i>Lespedeza floribunda</i> Bunge.	0.58	0.6	0.42	2	-	-	-	-	3.79	6.74	2.3	13
<i>Micromeria biflora</i> Bth.	7.97	5.1	3.1	16	65.46	24.71	6.32	97	19.3	8.2	2.5	30
<i>Mollago nudicaulis</i> Lamb.	0.32	0.6	0.24	14	-	-	-	-	-	-	-	-
<i>Oenothera rosea</i> Soland.	-	-	-	-	2.48	5.95	3.1	12	-	-	-	-
<i>Oxalis corniculata</i> L.	16.82	17.9	15.3	50	90.23	42.12	25.31	158	61.16	27.6	8.16	97
<i>Paspalum paspaloides</i> Scrib.	0.35	0.12	0.25	1	-	-	-	-	-	-	-	-
<i>Poa infirma</i> H.B.K.	36.6	44.7	29.3	91	-	-	-	-	-	-	-	-
<i>Polygala abyssinica</i> R.Br.	1.52	3.78	0.57	6	-	-	-	-	-	-	-	-
<i>Polygonum paronychioides</i> C.A. Mey ex Huben.	-	-	-	-	3.26	6.08	0.75	10	2.23	3.4	4.07	7
<i>Polypogon monspeliensis</i> (L.) Desf.	-	-	-	-	-	-	-	-	1.4	2.8	1.1	5
<i>Portulaca oleraceae</i> L.	0.29	0.8	0.07	1	-	-	-	-	-	-	-	-
<i>Rumex hastatus</i> D.Don.	-	-	-	-	6.29	7.19	15.35	29	-	-	-	-
<i>Setaria pumila</i> Roem & Schult	25.1	10.7	13.0	49	-	-	-	-	0.53	0.85	0.9	2
<i>Sida cordata</i> Boras	0.2	0.4	0.02	1	-	-	-	-	1.0	1.6	0.7	3
<i>Solanum nigrum</i> L.	-	-	-	-	-	-	-	-	1.06	2.2	0.2	4
<i>Sporobolus coromandelianus</i> Kunth.	0.03	0.12	0.02	0.2	-	-	-	-	-	-	-	-
<i>Stipa capensis</i> Thunb.	-	-	-	-	0.77	0.73	0.08	2	-	-	-	-
<i>Taraxacum officinale</i> Weber	-	-	-	-	0.36	0.47	0.75	2	-	-	-	-
<i>Theneda anathera</i> Hack	0.97	2.61	1.73	5	8.23	14.070	7.58	30	5.35	7.51	14.97	28
<i>Verbascum thapsus</i> L.	-	-	-	-	0.36	0.47	0.07	1	-	-	-	-
<i>Viola canescens</i> Wall. ex Roxb.	4.41	5.58	1.1	11	-	-	-	-	6.78	7.85	2.32	17

Table 7 (contd)

<u>Woody species</u>												
<i>Acacia modesta</i> Wall.	4.68	15.91	2.3	23	0.64	2.02	0.29	3	-	-	-	-
<i>Ailanthus altissima</i> Swingle	0.2	0.6	1.2	2	3.93	7.0	13.41	24	1.4	2.92	8.94	13
<i>Berberis lycium</i> Royle	5.69	8.7	2.32	17	40.39	41.97	4.21	87	-	-	-	-
<i>Carissa opaca</i> Stapf.	4.54	4.24	1.15	10	-	-	-	-	-	-	-	-
<i>Celtis australis</i> L.	-	-	-	-	1.18	1.69	0.1	3	-	-	-	-
<i>Clematis graveolens</i> Lindl.	0.03	0.12	0.02	2	-	-	-	-	2.04	4.03	1.57	8
<i>Colebrookea oppositifolia</i> Sm.	-	-	-	-	-	-	-	-	2.8	5.93	12.79	22
<i>Debregeasia salicifolia</i> Rendle.	0.1	0.22	0.01	0.3	0.36	0.47	0.74	2	-	-	-	-
<i>Desmodium motorium</i> Merrill.	-	-	-	-	2.4	2.1	0.2	5	-	-	-	-
<i>Dodonaea viscosa</i> L.	42.59	48.48	36.32	127	98.74	96.52	97.54	293	84.7	79.07	39.8	204
<i>Helicteres isora</i> L.	-	-	-	-	60.1	48.2	85.1	193	-	-	-	-
<i>Indigofera heterantha</i> Wall.	-	-	-	-	2.96	33.5	2.03	61	22.4	30.46	15.58	68
<i>Justicia adhatoda</i> L.	0.52	1.6	1.6	4	10.04	21.26	10.76	42	5.0	5.0	0.3	10
<i>Mallotus philippensis</i> Muell.	68.66	56.13	47.5	172	73.62	90.63	92.14	256	77.1	88.58	97.2	263
<i>Maytenus royleanus</i> Cufodontis.	0.52	1.6	1.6	4	10.04	21.26	10.76	42	5.0	5.0	0.3	10
<i>Mimosa himalayana</i> Gamble.	1.49	1.3	0.77	4	-	-	-	-	-	-	-	-
<i>Myrsine africana</i> L.	11.19	11.34	17.53	40	-	-	-	-	-	-	-	-
<i>Olea ferruginea</i> Royle	-	-	-	-	9.39	17.0	11.22	38	0.03	3.0	0.006	3
<i>Orostegia limbata</i> Boiss.	-	-	-	-	0.49	0.71	0.94	2	-	-	-	-
<i>Periaploca afhylla</i> Dene.	-	-	-	-	0.26	0.49	0.53	1	-	-	-	-
<i>Phyllanthus emblica</i> L.	1.61	1.6	0.62	4	-	-	-	-	-	-	-	-
<i>Pinus roxburghii</i> Sargent.	27.8	33.3	86.5	148	47.5	47.6	83.7	179	75.1	71.1	90.4	237
<i>Rubus ellipticus</i> Smith.	-	-	-	-	4.31	10.78	12.64	28	-	-	-	-
<i>Sageretia thea</i> var. <i>brandrethiana</i> Brongn.	1.86	1.9	1.6	5	4.23	6.96	11.92	23	9.83	12.85	11.60	34
<i>Tylophora hirsuta</i> Wight.	0.71	2.2	0.5	3	3.91	7.61	0.89	12	3.7	7.31	2.21	13
<i>Xanthium strumarium</i> L.	0.19	5.58	2.25	8	-	-	-	-	-	-	-	-
<i>Zanthoxylum alatum</i> Roxb.	-	-	-	-	1.18	3.39	0.2	5	-	-	-	-
<i>Zizyphus nummularia</i> Wight.	-	-	-	-	0.12	0.29	0.43	1	6.76	13.3	13.1	33
<i>Zizyphus oxyphylla</i> Edgew.	-	-	-	-	0.14	0.3	0.46	1	25.5	25.1	5.2	56

I. STREAM VEGETATION

This vegetation occupied the ravine bed and was clearly divisible into two communities.

1. SPRING VEGETATION

MENTHA-NASTURTIUM COMMUNITY

It occupied the water logged stretch between the rest house and the first water fall. The elevation at the beginning of the ravine near the rest house was 825 m but it gradually steeped down to 680 m near the water fall. The gradient varied from low to high according to the topography. The soil was sand dominated and waterlogged. It supported 12 herbaceous plants dominated by *Mentha longifolia* and *Nasturtium officinale*. Half of the importance value was reposed in these two plants alone (Table 8). *M.longifolia* is exceedingly common along water courses largely because of its fondness for water (Stewart,1972) and spreads quickly in moist sandy soils by suckers. *N.officinale*, popularly known as water cress, closely followed *M.longifolia*. It is an amphibious member of Brassicaceae from plains to 2,700 m (Stewart, 1972) and is abundantly found in clear slow running, shallow streams. The plant penetrates its adventitious roots easily in the sandy bed and then branches profusely. It can flourish equally well in a free floating form. Other plants of some importance were *Cannabis sativa*, *Oxalis corniculata* and *Themeda anathera*. These usually grew on raised areas scattered throughout the area. Among the woody plants flanking the area *Justicia adhatoda*, *Mallotus philippenis*, *Dodonaea viscosa* and *Acacia modesta* were included.

Table 8 Stream vegetation (spring flora) Phytosociological attributea of
Mentha-Nasturtium community

Name of Species	D	R.D	F	R.F	C.C	R.C.C	I.V
<i>Adiantum incisum</i>	5.5	3.3	0.04	2.4	2.0	0.6	6
<i>Anagallis arvensis</i>	4.7	2.9	0.04	2.4	2.75	0.9	6
<i>Cannabis sativa</i>	33.3	19.7	0.25	15.2	60.5	18.9	54
<i>Conyza bonariensis</i>	3.0	1.8	0.02	1.2	0.75	0.2	3
<i>Fimbristilis dichotomus</i>	1.0	0.6	0.01	0.4	18.75	5.9	7
<i>Mentha longifolia</i>	41.2	24.4	0.51	31.0	77.25	24.2	80
<i>Micromeria biflora</i>	2.8	1.7	0.02	1.2	3.75	1.2	4
<i>Nasturtium officinale</i>	34.8	20.6	0.44	26.7	72.75	22.8	70
<i>Oxalis corniculata</i>	23.9	14.1	0.18	10.9	21.5	6.7	32
<i>Setaria pumila</i>	1.7	1.0	0.01	0.6	6.75	2.1	4
<i>Themeda anathera</i>	12.2	7.2	0.09	5.5	48.0	15.0	28
<i>Tylophora hirsuta</i>	5.0	3.0	0.04	2.4	5.0	1.6	7

2. FALL VEGETATION

NASTURTIUM-MENTHA COMMUNITY

In fall the same area supported a community which consisted of 13 herbaceous species dominated by *N.officinale* and *M.longifolia* (Table 9). About 56 % of the total importance value was reposed in these two species. The same two plants also dominated the spring community. Only the order of dominance here was reversed because of the different growing seasons. *Bramia monnieri* and *Cynodon dactylon* were other herbaceous plants of some importance. The former is a common prostrate herb of wet soils ascending to 1220 m elevation (Stewart, 1972).

The perennial plants remained the same in both the seasons but with variable dominance as their active growing periods differ in the two seasons.

Table 9 Stream vegetation (fall flora) Phytosociological attributes of
Mentha-Nasturtium ^{MENTHA} community

Name of Species	D	R.D	F	R.F	C.C	R.C.C	I.V
<i>Bramia monnieri</i>	12.2	11.88	0.26	8.54	6.19	9.57	30
<i>Cannabis sativa</i>	5.4	5.26	0.25	8.12	2.19	3.39	17
<i>Ceterarch dalhousiae</i>	3.2	3.12	0.14	4.48	0.35	0.53	8
<i>Cynodon dactylon</i>	11.2	10.91	0.31	10.17	4.25	6.58	28
<i>Cyperus rotundus</i>	2.6	2.53	0.16	5.29	0.41	0.63	8
<i>Mentha longifolia</i>	26.2	25.51	0.7	22.73	21.44	33.17	81
<i>Nasturtium officinale</i>	30.7	29.89	0.56	18.29	25.69	38.2	86
<i>Oxalis corniculata</i>	3.8	3.70	0.14	4.48	3.75	5.80	14
<i>Plantago lanceolata</i>	0.4	2.39	0.05	1.62	0.13	0.19	2
<i>Polygonum paronychioides</i>	2.9	2.82	0.21	6.92	0.53	0.82	11
<i>Rumex hastatus</i>	0.5	0.49	0.05	1.62	0.13	0.19	2
<i>Sisymbrium irio</i>	0.3	0.29	0.03	0.82	0.06	0.10	1
<i>Xanthium strumarium</i>	1.8	1.75	0.16	5.29	0.41	0.63	8

1. SPRING VEGETATION

ARUNDO-MENTHA COMMUNITY

The area supporting this community started a little beyond the first water fall 1.5 km west of the rest house at 680 m elevation and after stretching for about 8 km ended at 540 m elevation. In the beginning the gradient was steep but became gentler and gentler with the distance. The community was dominated by *Arundo donax* and *Mentha longifolia* (Table 10).

Arundo donax is a perennial plant with woody rhizomes and high, erect, sparsely branched culms (Cope, 1982). It is found upto 1600 m elevation. It is a plant of wet habitat but is capable of growing in dryish ones if once established (Stewart, 1972). It is of very little use as a fodder though cattle may take a munch or two while passing by it.

As *A. donax* propagates profusely through underground suckers, it was impossible to determine and count the number of individuals. As such the values of only two community attributes, namely frequency and canopy coverage were added to get summation value. The accompanying 11 herbaceous plants were also similarly treated. On these bases more than 1/3rd summation value was reposed in *A. donax* alone and became the leading dominant.

At places, where the gradient was low and more coarse material had accumulated, large specimens of *A. donax* with a height of 4 m were seen. This hints at the extreme suitability of the habitat for its growth.

Mentha longifolia attained the second highest summation value but could not show its traits significantly because of its low capability of competing with *A. donax* under these conditions.

At places some woody plants like *Justicia adhatoda* and *D. viscosa* were found mixed with *A. donax*. They usually made their abodes on the raised mounds formed by the accumulation of soil and/or decomposed organic matter held up by the interwoven rhizomatous

bases of *A. donax*. Other woody species occurring on the flanks of the stream were *Mallotus philippensis*, *Desmodium motorium*, *Debregeasia salicifolia*, *Carissa opaca* and *Acacia modesta*. There were more *M. philippensis* and *M. himalayana* on the southern flank of the stream while the northern flanks supported more *D. viscosa*. *M. himalayana* was exclusively confined to the north-facing slopes. Some large specimens of *M. philippensis* and *Sageretia thea* var. *brandrethiana* were noticed. High bushes of *M. himalayana* and tree like *A. modesta* and *D. motorium* indicated that the area was well suited for the growth of these plants. *Ziziphus oxyphylla* was also seen. A few rare specimens of *Allanthus altissima*, *Cassia fistula* and *Phoenix humilis* were seen while among the rare herbaceous plants *Themeda anathera*, *Sisymbrium irio* and *Conyza bonariensis* were recorded.

The Arundo thicket became less dense at 600 m elevation before reaching the end of the stream. The slopes flanking the stream became gentle (18-20°) and big boulders were present in and on the banks of the stream. At an elevation of 550 m the Arundo zone ended completely and the ravine opened up widely to merge into the dry stream (Khawar). *M. longifolia*, *M. sylvestris*, *D. salicifolia*, *S. Thea* var. *brandrethiana*, *J. adhatoda*, *D. viscosa*, *Polygonum plebejum*, *S. irio*, *N. officinale* and grasses like *Cynodon dactylon* and *Cymbopogon schoenanthus* were common here. A few *Salix* sp and some trees of *Ficus palmata* were also noticed.

Table 10 Stream vegetation (spring flora) Phytosociological attributes of
Arundo-Mentha community

Name of Species	F	R.F	C.C	R.C.C	Summation Value
<i>Apluda mutica</i>	0.02	0.84	0.5	0.16	1
<i>Arundo donax</i>	0.75	36.91	223.67	74.09	111
<i>Bramia monnieri</i>	0.02	1.03	0.28	0.09	1
<i>Cannabis sativa</i>	0.19	9.45	9.06	3.00	12
<i>Cynodon dactylon</i>	0.02	0.84	0.78	0.26	1
<i>Cyperus niveus</i>	0.05	2.46	1.72	0.57	3
<i>Equisetum ramosissimum</i>	0.05	2.26	1.17	0.39	3
<i>Euphorbia hirta</i>	0.02	0.84	0.22	0.29	1
<i>Mentha longifolia</i>	0.56	27.71	52.89	17.52	45
<i>Nasturtium officinale</i>	0.16	7.78	5.11	1.69	9
<i>Oxalis corniculata</i>	0.11	5.56	4.22	1.4	7
<i>Polygonum plebejum</i>	0.09	4.33	2.28	0.76	5

2. FALL VEGETATION

ARUNDO-NASTURTIIUM COMMUNITY

Beside *Arundo donax*, 16 herbaceous species were recorded in the fall season (Table 11). *A. donax* was found contributing about 34% of the total summation value followed by the herbaceous members like *Nasturtium officinale* and *Mentha longifolia* which contributed 20% and 17% of the total summation value. The remaining 29% value was shared by the rest of the 14 species. This indicates a strong dominance of the 3 above mentioned species in this community. Some grasses like *Themeda anathera* and *Cynodon dactylon* were common in this season than in the spring.

The entire stretch of the ravine was under a high biotic pressure. Fuel wood extraction and grazing by goats and other heavy ungulates were very common. Gujar women very frequently visited the stream for washing, laundrying and to fetch drinking water due to which numerous approaches and paths were clearly visible throughout the area. The vegetation thus was highly disturbed.

Table 11 Stream vegetation (fall flora) Phytosociological attributes of
Arundo-Nasturtium community

Name of Species	F	R.F	C.C	R.C.C	Summation Value
<i>Adiantum incisum</i>	0.11	3.45	3.2	0.54	4
<i>Arundo donax</i>	0.67	21.00	274.0	46.02	67
<i>Cannabis sativa</i>	0.08	2.51	1.6	0.27	3
<i>Ceterarch dalhousie</i>	0.82	0.63	0.4	0.007	1
<i>Cynodon dactylon</i>	0.1	3.13	11.6	1.95	5
<i>Cyperus rotundus</i>	0.15	4.70	3.8	0.64	5
<i>Equisetum ramosissimum</i>	0.03	0.94	0.6	0.10	1
<i>Erigeron alpinus</i>	0.03	0.94	0.6	0.1	1
<i>Euphorbia indica</i>	0.08	2.51	1.6	0.27	3
<i>Mentha longifolia</i>	0.58	18.18	90.8	15.25	33
<i>Nasturtium officinale</i>	0.50	15.67	136.4	22.91	39
<i>Oxalis corniculata</i>	0.06	1.88	8.8	1.48	3
<i>Polygonum paronychioides</i>	0.29	9.09	8.8	1.48	11
<i>Scirpus mucronatus</i>	0.03	0.94	0.6	0.1	1
<i>Sisymbrium irio</i>	0.02	0.63	0.4	0.07	1
<i>Themeda anathera</i>	0.17	5.33	20.4	3.43	9
<i>Xanthium strumarium</i>	0.17	5.33	12.0	0.02	7

II. NORTH FACING

North facing slope, after reaching its maximum elevation at 1350 m, flattened and gently steeped down to form a plateau supporting two large size villages, namely Koi and Takhto. The soil was generally deep and moist and the site cool and shady. The entire slope was divisible into two portions supporting separate communities.

A. LOWER SLOPES

1. SPRING VEGETATION

MALLOTUS-DODONAEA-THEMEDA COMMUNITY

The lower gentle slopes between 550 and 840 m elevation were inhabited by *Mallotus-Dodonaea-Themeda* community with *Mallotus philippensis*, *Dodonaea viscosa* and *Themeda anathera* as the dominant plants.

The soil was loamy with very high calcium and magnesium contents and was slightly acidic. The electrical conductivity was high hinting at high concentration of salts in the soil (Table 12).

Among the tree strata *Mallotus philippensis*, locally known as Kamila, took the lead by acquiring the highest importance value among the trees (Table 13). It is a small evergreen tree of the sub-Himalayan tract and outer Himalaya ascending to 1500 m elevation and is one of the commonest plants both in the forest and on grazing grounds or waste places as the leaves are impalatable and hence escape grazing even by goats. This largely explains its prevalence (Parker, 1956). However it becomes an easy target of the fuel hunter's axe as it yields good fuel wood. Kamila does not allow grasses to grow near it and is frost hardy. It reproduces copiously by seeds and root suckers, form large thickets especially along water courses and can withstand considerable shade (Troup, 1921).

Table 12 Soil characteristics

SLOPES ----->	NORTH FACING		SOUTH FACING				EAST FACING		
	(L)	(M)	(L.M)	(L)	(M)	(U)	(L)	(M)	(U)
<u>Soil Parameters</u>									
Saturation Percentage (S.P)	42.00	51.10	49.00	45.00	46.00	30.00	32.00	35.00	35.00
pH	6.3	6.2	6.3	6.2	6.1	6.0	6.5	6.3	6.0
Electrical + Conductivity (E.C)	0.36	0.32	0.39	0.34	0.50	0.10	0.21	0.10	0.10
Na meq/1	0.37	0.32	0.34	0.42	0.11	0.27	0.60	0.22	0.22
Ca meq/1	3.20	2.12	2.50	1.92	4.00	1.60	0.80	1.70	1.90
Ca Mg meq/1	3.40	2.90	3.80	3.15	5.75	4.00	2.75	2.00	4.00
Sodium Absorption Ratio [S.A.R.]	0.21	0.28	0.27	0.31	0.75	0.19	0.22	0.30	0.16
Organic Matter [O.M]	1.48	1.74	1.47	1.83	2.02	2.45	0.62	1.33	2.34
Sand %	47.75	53.07	57.63	57.82	64.63	56.74	63.51	59.20	57.91
Silt %	44.70	38.88	33.33	36.42	28.83	34.17	27.56	32.31	33.21
Clay %	7.55	8.05	9.04	9.76	6.54	9.09	8.93	8.49	8.88
Texture	Loam	Sandy Loam	Sandy Loam	Sandy Loam	Loamy Sand	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam

+ Electrical conductivity of soil extract in m.mhos/cm at 25A

L.M = Lowermost slopes

L = Lower slopes

M = Middle slopes

U = Upper slopes

M. Philippensis was found regenerating at this lower slope as indicated by the presence of a large number of saplings but the maximum girth size class could not go beyond 25 cm CBH (Table 14) which hints at high biotic disturbance in the recent past.

Dodonaea viscosa emerged as a first dominant among the shrubby flora. The density of *D. viscosa* was almost double than that of *M. philippensis* although their frequencies were the same. This reflects on the gregarious nature of the plant. *D. viscosa* is a tall shrub, sometimes 4-5 m high and coppices well from the cut stumps often to the exclusion of other plants. It is immune to grazing but the plant is much reliable as a fuel wood firstly because its resinous young shoots burn readily and secondly it is a plant of small dimension which does not require splitting. The early growth is faster in length than in diameter (Parker, 1956). The rapid growth and the gregarious nature make *D. viscosa* an excellent competitor of other plants (Abdullah, 1973).

The seeds of *D. viscosa* are viable but the deteriorated conditions and biotic interferences such as cutting, grass harvesting and grazing may impede their germination (Hussain *et al.*, 1991).

Themeda anathera was the dominant member from the herbaceous layer. It is a densely tufted grass with creeping rhizomes (Cope, 1982) and is a good fodder grass of the dryish soils between 1500-3000 m (Bor, 1960). Species of *Themeda* (*T. tremula*) is known to withstand considerable soil moisture stress but requires high soil moisture for its satisfactory growth (Amarsinghe and Pemadasa, 1982). This condition was prevalent on the north facing aspect and may be one of the reasons for the dominance of *T. anathera* here.

Gnaphalium affine, another herb, closely followed *T. anathera* on this slope. *G. affine* is a small sized herb with xerophytic characters and is fond of dry, arid and exposed sandy soils. It is one of the pioneers in a successional series on dry beds (Simon, 1984) and can colonize even rocky debris without any soil (Ahmad, 1986).

The community, as a whole, supported 10 woody and 29 herbaceous species. The woody plants, beside *M.philippensis* and *D.viscosa* included *Debregeasia salicifolia*, *Sageretia thea* var. *brandrethiana*, *Justicia adhatoda* and *Acacia modesta*. A few plants of *Myrsine africana* and *Mimosa himalayana* were also present. All these species are mostly found on the dry, exposed lower slopes and showed xerophytic characters. *J. adhatoda* was especially abundant on the lower denuded soils. *M. himalayana* is a common plant of ravines upto 1220 m (Parker, 1956). On this aspect of the ravine it occupied a belt between 600-900 m.

Among the rare plants were included *Carissa opaca*, *Zizyphus nummularia*, *Flacourtia indica* and *Ailanthus altissima*. *D.viscosa* had thickly populated the north facing aspect. It had started from the base of the ravine and entering the pine zone at 825 m, had covered the area upto the top elevations. At some places it was thinned down due to cutting as indicated by the presence of cut stumps. All the above mentioned plants were present interspersed with *D.viscosa* on the lower slopes but at higher elevations, where these woody plants could not climb, only *M.philippensis* accompanied *D.viscosa*. The former however, mostly followed the moisture gradient on the slopes and was therefore abundant along dry or wet water channels.

Eleven different grasses were included in the herbaceous vegetation out of which four showed higher importance values. They were *Cymbopogon schoenanthus*, *Poa infirma*, *Themeda anathera* and *Aristida cyanantha*. These palatable annual or perennial grasses were knee high in spring and were a great source of attraction to the grazing animals.

Table 13 North-facing, Lower slopes (spring vegetation) Phytosociological attributes of *Mallotus-Dodonaea-Themeda* community

Name of Species	D	R.D	F	R.F	C.C	R.C.C	I.V
<i>Anagallis arvensis</i>	0.67	1.31	0.03	1.79	0.77	0.42	4
<i>Arenaria serpyllifolia</i>	2.73	5.32	0.08	4.78	3.59	1.95	12
<i>Aristida adscensionis</i>	0.56	1.09	0.05	2.99	9.09	4.95	9
<i>Artimisia scoparia</i>	0.05	0.10	0.007	0.42	0.14	0.08	0.6
<i>A.sativa</i>	0.02	0.04	0.002	0.12	0.05	0.03	0.2
<i>Chenopodium album</i>	0.04	0.08	0.002	0.12	0.05	0.03	0.2
<i>Conyza bonariensis</i>	0.33	0.64	0.03	1.79	0.64	0.35	3
<i>Cymbopogon schoenanthus</i>	1.4	2.73	0.09	5.38	24.18	13.16	21
<i>Cynodon dactylon</i>	0.02	0.04	0.002	0.12	0.05	0.03	0.2
<i>Cyperus rotundus</i>	0.09	0.18	0.005	0.3	0.09	0.05	0.5
<i>Dicliptera roxburghiana</i>	0.22	0.43	0.025	1.5	0.73	0.4	2.0
<i>Eriogrostis pilosa</i>	0.25	0.49	0.016	0.96	2.05	1.12	3
<i>Erodium cicutarium</i>	5.25	10.23	0.166	9.93	12.68	6.9	27
<i>Gagea elagans</i>	0.51	0.99	0.02	1.2	0.68	0.37	3
<i>Gallium aparine</i>	1.16	2.26	0.09	5.38	2.27	1.24	9
<i>Gnaphalium affine</i>	16.33	31.81	0.25	14.95	21.45	11.68	58
<i>Lactuca dissecata</i>	1.16	2.26	0.07	4.10	1.64	0.89	7
<i>Medicago orbicularis</i>	0.09	0.18	0.007	0.42	0.14	0.08	0.7
<i>Micromeria biflora</i>	5.89	11.47	0.1	5.98	4.91	2.67	20
<i>Oxalis corniculata</i>	7.53	14.67	0.205	12.26	8.32	4.53	32
<i>Phalaris minor</i>	0.15	0.29	0.007	0.42	0.14	0.08	0.8
<i>Poa infirma</i>	2.65	5.16	0.091	5.44	4.05	2.2	13
<i>Polygonum paronychioides</i>	0.05	0.1	0.002	0.12	0.14	0.08	0.3
<i>Rumex hastatus</i>	0.04	0.08	0.002	0.12	0.68	0.37	0.6
<i>Scirpus mucronatus</i>	0.02	0.04	0.002	0.12	0.05	0.03	0.2
<i>Setaria pumila</i>	0.09	0.18	0.002	0.12	0.05	0.03	0.3
<i>Sonchus asper</i>	0.07	0.14	0.009	0.54	0.18	0.1	0.8

<i>Stipa capensis</i>	0.09	0.18	0.005	0.3	0.09	0.05	0.5
<i>Themeda anathera</i>	3.76	7.33	0.3	17.9	83.91	45.67	71

WOODY SPECIES

<i>Acacia modesta</i>	0.03	5.04	0.68	13.5	0.09	2.8	21
<i>Debregeasia salicifolia</i>	0.08	13.45	0.68	13.5	0.23	7.2	34
<i>Desmodium motorium</i>	0.008	1.35	0.006	0.12	0.06	0.13	2
<i>Dodonaea viscosa</i>	0.26	43.7	0.91	18.1	1.5	46.7	109
<i>Justicia adhatoda</i>	0.03	5.04	0.77	15.3	0.10	3.1	23
<i>Mallotus philippensis</i>	0.13	21.8	0.95	18.9	1.03	32.1	73
<i>Mimosa himalayana</i>	0.006	1.01	0.14	2.8	0.04	1.3	5
<i>Myrsine africana</i>	0.009	1.51	0.32	6.3	0.04	1.3	9
<i>Otostegia limbata</i>	0.002	0.34	0.002	0.04	0.07	2.3	3
<i>Sageretia thea</i> var. <i>brandrethiana</i>	0.05	8.22	0.59	11.4	0.18	5.47	25

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2. FALL VEGETATION

MALLOTUS-DODONAEA-POA COMMUNITY

The woody dominants of this community were the same as that of the spring vegetation discussed earlier but from amongst the ground flora *Poa pratensis* replaced *Themeda anathera*.

A severe attack of caterpillars was noticed in the fall season particularly on *Dodonaea viscosa* and *Debregeasia salicifolia* which were completely denuded and defoliated. Even the young twigs of these plants were not spared. Other plants, however, were not affected.

Mallotus philippensis became the leading dominant of the arborescent species as, being a tree, it presented a very high canopy cover value (Table 15). It was well regenerating and a large number of very young specimens were found scattered all over the area.

D. viscosa received the highest importance value throughout the community. This was contributed by all the three parameters particularly the density and frequency. The plant was found abundantly regenerating. *D. viscosa*, however, is a very favourite fuel wood and was therefore always found in a bushy form. Those which had escaped the axe, had fallen victims to the devastating attack of the caterpillars.

Poa pratensis was introduced in the temperate hills of Indo-Pakistan sub-continent where it has established as a wild or pasture grass capable of being made into hay for off season use (Bor, 1960). Cattle dung deposition in autumn increases establishment of *P. pratensis* (Welch, 1985). Controlled burning and grazing greatly favour its performance (Edroma, 1984). It spreads vegetatively by lateral tillers (Fowler, 1982) and is very common in highly trampled area (Siniscalco and Montacchini, 1983/1984). It is however of no consequence as a fodder grass (Cope, 1982) and therefore becomes abundant in grazing grounds like these.

Aristida cyanantha, a close competitor of *P.pratensis* in this community, is a bushy grass which appears soon after rains. It favours sloping, loamy or silty clay and non saline soils (Hussain, 1964) but grows well in dry places or stony beds of dried up streams (Bor, 1960).

Cyperus niveus was another grass of high importance value. Stewart (1967) has also reported it from this area. It is a plant of exposed places, rarely found in shade (Salim and Shahid, 1973).

Myrsine semiserrata was solely present on this aspect at lower slopes near the moist ravine which confirms the findings of Parker (1956). Most of the plants were very young but large size individuals were also present.

Mimosa himalayana was also present exclusively on this aspect. Parker (1956) reports this plant to be common in ravines and grasslands upto an elevation of 1200 m.

Some rare plants included *Ailanthus glandulosa*, *Ziziphus sativa*, *Salmalia malabarica*, *Chrysopogon schoenanthus*, *Cenchrus ciliaris*, *Cynodon dactylon*, *Mollugo nudicaulis*, *Asparagus gracilis*, *Desmodium motorium*, *Erigeron alpinus*, *Geranium ocellatum*, *Portulaca oleraceae*, *Eragrostis pilosa*, *Phoenix humilis*, *Micromeria biflora* and *Setaria pumila*.

Table 15 North-facing, Lower slopes (fall vegetation) Phytosociological attributes of *Mallotus-Dodonaea-Poa* community

Name of Species	D	R.D	F	R.F	C.C	R.C.C	I.V
<i>Amaranthus viridis</i>	0.1	0.2	0.006	0.22	0.1	0.12	0.4
<i>Aristida cyanantha</i>	14.7	29.7	0.67	24.7	204.9	24.2	79
<i>Cheilanthes pteridiodes</i>	2.1	4.2	0.17	6.3	45.1	5.3	16
<i>Chenopodium album</i>	0.2	0.4	0.02	7.4	2.0	0.2	8.0
<i>Conyza bonariensis</i>	1.3	2.6	0.12	4.4	10.9	1.3	8
<i>Crotalaria medicaginea</i>	0.04	0.08	0.006	0.22	0.1	0.012	0.3
<i>Cyperus niveus</i>	4.5	9.1	0.42	15.5	144.0	17.0	42
<i>Gallium aparine</i>	0.1	0.2	0.01	0.4	0.2	0.024	0.6
<i>Geranium ocellatum</i>	0.1	0.2	0.02	7.4	3.0	0.4	8
<i>Micromeria biflora</i>	0.6	1.2	0.04	1.5	17.6	2.1	5
<i>Oxalis corniculata</i>	3.4	6.9	0.29	10.7	111.1	13.1	31
<i>Poa pratensis</i>	18.1	36.6	0.67	24.7	247.8	29.3	91
<i>Setaria pumila</i>	1.6	3.2	0.16	5.9	47.3	5.6	15
WOODY SPECIES							
<i>Acacia modesta</i>	0.04	6.4	0.33	11.13	0.05	1.2	19
<i>Carissa opaca</i>	0.03	4.81	0.16	5.4	0.04	0.94	11
<i>Debregeasia salicifolia</i>	0.04	6.4	0.006	0.29	0.3	7.1	14
<i>Dodonaea viscosa</i>	0.24	38.5	0.78	26.3	0.84	19.8	85
<i>Justicia adhatoda</i>	0.04	6.4	0.67	22.6	0.52	12.2	41
<i>Mallotus philippensis</i>	0.16	25.64	0.56	18.89	1.57	36.94	81
<i>Mimosa himalayana</i>	0.004	0.64	0.05	1.7	0.03	0.71	3
<i>Myrsine africana</i>	0.01	1.6	0.38	12.82	0.4	9.42	12
<i>Sageretia thea</i> var. <i>brandrethiana</i>	0.06	9.6	0.03	1.0	0.5	11.76	34
<i>Sida cordata</i>	0.01	1.6	0.001	0.03	0.02	0.47	2

B. MIDDLE SLOPES

1. SPRING VEGETATION

PINUS-DODONAEA-MICROMERIA COMMUNITY

Pinus-Dodonaea-Micromeria community was confined between 880 m and 1350 m elevation and was dominated by *Pinus roxburghii*, *Dodonaea viscosa* and *Micromeria biflora*. The soil was sandy loam with the highest saturation percentage in all the communities (Table 12). The gradients were steeper than the lower slopes.

P. roxburghii showed the highest importance value solely because of its great canopy cover, otherwise its frequency was equal to and the density almost half that of *D. viscosa*, the shrubby dominant member of the community. (Table 16). *P. roxburghii* grows best on well drained, deep porous soils such as sandy loams having sand or mica in a high proportion (Troup, 1921). It grows on all types of rocks such as granite, conglomerates, sandstones, gneiss or schists but avoids damp hollows, poorly drained heavy soils or soils overlying limestone (Parker, 1956). It particularly favours ridges and crests (Beg, 1978). Pines are, however, absent on denuded steep slopes as their seeds are washed away before they can germinate. Seeds are shed in hot weather and the monsoon rains help greatly in their germination. Pure pine forests occur between 610 and 1850 m elevation (Stewart, 1972).

P. roxburghii was found regenerating as indicated by the presence of young saplings. Most of the pine trees of this zone were mature and the maximum concentration of girth size class was between 80 cm and 240 cm (Table 17) which indicates that the forest had remained well protected in the past but is now biotically disturbed hence the girth size classes below 80 cm were a little less in number.

Dodonaea viscosa became dominant from the shrubby layer. Because of the greater fuel value of this plant and the adverse effect of shade cast by the arborescent members,

D. viscosa had retreated into oblivion. However it was found fully regenerating as numerous saplings of this plant were encountered. Some individuals in protected or inaccessible regions had grown to girth size upto 45 cm (Table 14) and appeared as short statured trees.

D. viscosa is a common undergrowth species of *P. roxburghii*. It also avoids traps and favours sandstone and kankar soils and its capacity for growing on poor dry soils together with its immunity from browsing explains its abundance over large areas (Troup, 1921).

Mallotus philippensis also showed a high importance value as compared to the other woody species. It ascends occasionally to nearly 5,000 m into the region of *P. roxburghii* (Troup, 1921) and is one of the commonest plants in the zone it occupies (Parker, 1956). *Berberis lycium*, *Debregeasia salicifolia*, *Sageretia thea* Var. *brandrethiana*, *Zanthoxylum alatum*, *Carissa opaca* and *Ailanthus altissima* were other woody plants. *Phoenix humilis*, *Acacia modesta*, *Indigofera heterantha*, *Rubus ellipticus* and *R. niveous* also came across occasionally.

Micromeria biflora emerged as a leading member from the herbaceous flora. This plant was found all over the slope especially in moist and shady places and was particularly abundant on the high elevation.

The site was adjacent to the Police Station and was probably better protected from grazing and lumbering.

Table 16 North-facing, Middle slopes (spring vegetation) Phytosociological attributes of
Pinus-Dodonaea-Micromeria community

Name of Species	D	R.D	F	R.F	C.C	R.C.C	I.V
<i>Achyranthus aspera</i>	0.03	0.07	0.007	0.22	0.07	0.04	0.3
<i>Adiantum incisum</i>	2.61	7.05	0.136	4.28	2.47	1.44	13
<i>Ajuga bracteosa</i>	0.13	0.33	0.031	0.98	0.29	0.17	2
<i>Allium rubellum</i>	0.036	0.1	0.01	0.32	0.09	0.05	1
<i>Anagallis arvensis</i>	1.2	3.24	0.07	2.21	2.2	1.28	7
<i>Arenaria serpyllifolia</i>	0.96	2.6	0.024	0.76	2.13	1.24	5
<i>Aristide cyanantha</i>	0.74	2.0	0.145	4.57	4.47	2.61	9
<i>Artimisia scoparia</i>	0.036	0.1	0.007	0.22	0.18	0.11	1
<i>Bromus japonicus</i>	0.773	2.09	0.076	2.39	1.36	0.79	5
<i>Calendula arvensis</i>	0.32	0.86	0.06	1.89	1.47	0.86	4
<i>Cannabis sativa</i>	0.347	0.94	0.05	1.58	1.02	0.6	3
<i>Ceterach dalhousiae</i>	1.16	3.13	0.07	2.21	1.07	0.62	6
<i>Chenopodium album</i>	0.009	0.02	0.002	0.06	0.02	0.01	0.1
<i>Cirsium arvense</i>	0.009	0.02	0.002	0.06	0.13	0.08	0.2
<i>Conyza bonariensis</i>	0.169	0.46	0.04	1.26	1.04	0.61	2
<i>Cynodon dactylon</i>	0.169	0.46	0.024	0.76	1.6	0.93	2
<i>Cyperus rotundus</i>	0.133	0.36	0.01	0.32	0.09	0.05	1
<i>Dicliptera roxburghiana</i>	0.88	2.38	0.152	4.79	4.04	2.36	10
<i>Erodium cicutarium</i>	0.04	0.11	0.012	0.38	0.11	0.06	1
<i>Gallium aparine</i>	1.64	4.43	0.214	6.74	1.27	0.74	12
<i>Geranium ocellatum</i>	2.13	5.75	0.20	6.3	6.49	3.79	16
<i>Gnaphalium affine</i>	1.05	2.83	0.1	3.15	2.36	1.38	7
<i>Heliotropium europaeum</i>	0.053	0.14	0.014	0.44	0.13	0.08	1
<i>Inula cappa</i>	0.053	0.14	0.01	0.32	0.09	0.05	1
<i>Koelaria gracilis</i>	1.42	3.83	0.09	2.84	2.42	1.41	8
<i>Lathyrus erectus</i>	0.36	1.0	0.05	1.58	1.3	0.76	3
<i>Medicago orbicularis</i>	0.27	0.07	0.002	0.06	0.13	0.08	0.2
<i>Micromeria biflora</i>	9.16	24.7	0.302	9.51	6.2	3.62	38

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<i>Oxalis corniculata</i>	5.298	14.3	0.26	8.19	7.7	4.5	27
<i>Poa infirma</i>	0.116	0.31	0.005	0.16	0.6	0.35	1
<i>Rumex hastatus</i>	0.018	0.05	0.005	0.16	0.89	0.52	1
<i>Setaria pumila</i>	0.027	0.07	0.002	0.06	0.02	0.01	0.1
<i>Silene arinosa</i>	0.009	0.02	0.002	0.06	0.02	0.01	0.1
<i>Sonchus asper</i>	0.009	0.02	0.002	0.06	0.02	0.01	0.1
<i>Stipa capensis</i>	0.05	0.13	0.005	0.16	0.04	0.02	0.3
<i>Taraxacum officinale</i>	0.044	0.12	0.012	0.38	0.11	0.06	1
<i>Themeda anathera</i>	2.08	5.6	0.27	8.51	27.58	16.11	30
<i>Torilis leptophylla</i>	0.213	0.6	0.04	1.26	0.49	0.29	2
<i>Viola canescens</i>	1.27	3.43	0.105	3.31	1.53	0.89	8

WOODY SPECIES:

<i>Ailanthus altissima</i>	0.0006	0.29	0.02	0.7	0.15	0.16	1
<i>Asparagus gracilis</i>	0.009	0.03	0.002	0.07	0.02	0.02	0.1
<i>Berberis lycium</i>	0.015	7.3	0.29	10.5	0.17	0.2	18
<i>Carissa opaca</i>	0.001	0.49	0.02	0.7	0.01	0.01	1
<i>Colebrookea oppositifolia</i>	0.001	0.49	0.002	0.07	0.33	0.33	1
<i>Debregeasia salicifolia</i>	0.002	0.97	0.07	2.5	0.008	0.008	4
<i>Dodonaea viscosa</i>	0.075	36.6	0.79	28.7	0.38	0.3	66
<i>Mallotus philippensis</i>	0.073	30.6	0.79	23.7	0.58	0.5	55
<i>Otostegia limbata</i>	0.001	0.49	0.01	0.4	0.45	0.45	1
<i>Pinus roxburghii</i>	0.035	17.1	0.67	24.4	92.52	97.3	139
<i>Plectranthus rugosus</i>	0.002	0.97	0.005	0.18	0.04	0.04	1
<i>Sageretia thea</i> var. <i>brandrethiana</i>	0.001	0.49	0.05	1.8	0.03	0.03	2
<i>Tylophora hirsuta</i>	0.001	0.49	0.02	0.7	0.04	0.04	1
<i>Xanthium strumarium</i>	0.002	0.97	0.05	1.8	0.2	0.2	3
<i>Zanthoxylum alatum</i>	0.002	0.97	0.05	1.8	0.2	0.22	3

2. FALL VEGETATION

PINUS-DODONAEA-SETARIA COMMUNITY

Pinus-Dodonaea-Setaria community supported 12 woody and 23 herbaceous species (Table 18). *Pinus roxburghii*, due to its very high canopy cover, took the lead, although the frequency of *Mallotus philippensis*, a close arboreal competitor, was equal to and its density much higher than those of *P. roxburghii*. *M. philippensis*, a co-dominant tree was abundantly present but mostly followed dry or perennial water courses. Therefore the frequency did not match its high density. Moreover, being a favourite fuel wood, it was always found in a deformed bushy shape.

At about 1150 m elevation *Berberis lycium* staged its entry. It was bushy and had very low values of density, frequency and canopy cover. Other rare woody plants included *Celtis australis*, *Clematis graveolens*, *Maytenus royleanus* and *Phyllanthus emblica*. *Setaria pumila*, the herbaceous dominant, has also been reported (Cope, 1982) from this area. It is an annual weedy grass of the tropical and warm temperate regions which emerges between April and June (Wiese, 1985) and reaches its peak in August (Ognjanovic and Saric, 1988). It was most common between 800 and 1100 m elevations on this slope and showed high values of density and canopy cover.

Closely tailing are *Adiantum incisum* and *Aristida adscensionis*. The former is a fern of moist and shady habitat while the latter was a common grass of this aspect. Other herbs of relatively less importance were *Oxalis corniculata*, *Themeda anathera*, *Cynodon dactylon* and *Micromeria biflora*. Among rare plants were *Cyperus niveus*, *Verbascum thapsus*, *Ficus palmata*, *Arisaema jacquemontii*, *Achyranthus aspera*, *Rubus ellipticus*, *Barleria cristata*, *Euphorbia indica*, *Zanthoxylum alatum*, *Chrysopogon serrulatus*, *Boerhaavia coccinea*, *Nyctanthes arbor-tristis* and *Mollugo nudicaulis*. A fern, *Suzugenia*, originally a native of Chitral, was also noticed here.

Table 18 North-facing, Middle slopes (fall vegetation) Phytosociological attributes of *Pinus-Dodonaea-Setaria* community

Name of Species	Density	R.D.	Frequency	R.F.	Canopy coverage	R.C.C.	I.V.
<i>Adiantum incisum</i>	4.78	17.56	0.41	12.58	10.1	18.18	48
<i>Aristida adscensionis</i>	1.59	9.29	0.41	12.58	11.64	20.96	43
<i>Bidens chinensis</i>	0.06	0.22	0.03	0.92	0.14	0.25	1
<i>Cannabis sativa</i>	0.02	0.07	0.01	0.21	0.06	0.11	1
<i>Cenchrus ciliaris</i>	0.33	1.2	0.04	1.23	0.5	0.9	3
<i>Chrysopogon serrulatus</i>	0.44	1.62	0.22	6.8	4.14	7.45	16
<i>Convolvulus arvensis</i>	0.01	0.04	0.006	0.18	0.03	0.05	0.2
<i>Cynodon dactylon</i>	1.37	5.04	0.28	8.59	1.8	3.24	17
<i>Dicliptera roxburghiana</i>	0.02	0.07	0.01	0.31	0.33	0.59	1
<i>Erigeron alpinus</i>	0.17	0.62	0.07	2.15	0.38	0.65	3
<i>Erigeron pilosa</i>	0.7	2.6	0.02	0.61	0.12	0.22	3
<i>Euphorbia helioscopia</i>	0.01	0.04	0.006	0.18	0.03	0.05	0.3
<i>Euphorbia indica</i>	0.01	0.04	0.006	0.18	0.03	0.05	0.3
<i>Geranium ocellatum</i>	0.26	0.96	0.13	3.99	0.28	0.5	6
<i>Lespedeza floribunda</i>	0.18	0.66	0.03	0.92	0.7	1.26	3
<i>Micromeria biflora</i>	2.1	7.72	0.18	5.52	1.7	3.1	16
<i>Mollugo nudicaulis</i>	0.1	0.36	0.03	0.92	0.39	0.7	2
<i>Oxalis corniculata</i>	3.09	11.32	0.36	11.04	3.6	6.48	29
<i>Paspalum paspaloides</i>	0.11	0.40	0.006	0.18	0.42	0.76	1
<i>Portulaca oleracea</i>	0.09	0.33	0.04	1.23	0.11	0.2	2
<i>Setaria pumila</i>	6.8	25.0	0.24	7.36	12.3	22.15	55
<i>Themeda anathera</i>	1.3	4.78	0.2	6.13	3.86	6.92	18
<i>Viola canescens</i>	1.27	4.69	0.09	2.8	1.42	2.56	10
WOODY SPECIES							
<i>Barlaria cristata</i>	0.001	0.52	0.02	0.8	0.05	0.52	2
<i>Berberis lycium</i>	0.01	5.15	0.2	8.2	2.1	2.38	16
<i>Carissa opaca</i>	0.001	0.52	0.02	0.82	1.0	1.14	3
<i>Celtis australis</i>	0.001	0.52	0.01	0.41	0.5	0.57	0.2

<i>Clematis graveolens</i>	0.0001	0.05	0.001	0.04	0.05	0.06	0.2
<i>Dodonaea viscosa</i>	0.03	15.48	0.6	24.52	3.8	4.3	44
<i>Mallotus philippensis</i>	0.08	41.24	0.8	32.76	9.4	10.67	85
<i>Maytenus royleanus</i>	0.001	0.52	0.01	0.41	1.0	1.14	2
<i>Phyllanthus emblica</i>	0.001	0.52	0.001	0.04	0.05	0.06	0.1
<i>Pinus roxburghii</i>	0.05	25.8	0.8	32.76	70.2	79.7	138
<i>Tylophora hirsuta</i>	0.002	1.0	0.01	0.41	0.08	0.1	2
<i>Xanthium strumarium</i>	0.003	1.5	0.02	0.82	0.04	0.05	2

III. SOUTH FACING ASPECT

Among the three aspects discussed this was the largest, highly exposed and most disturbed one. The base started at 540 m elevation and the highest peak, known as Gishar Sar, culminated at 1905 m. The gradient rose steeply to about 1200 m where it flattened into a shallow bowl shaped plateau. This provided some flat land for cultivation and to harbour two large Gujar villages called Tanoor and Tangu. A number of perennial springs originated in the surrounding mountains slopes and the water trickled down centripetally to the northern end of the villages to form a large stream. The fast flow of water was checked down due to the flat topography and thus became easily manageable by the local inhabitants for cultivation purposes. It then rushed down the slope ending in a large water fall at the base of the gorge already discussed under stream vegetation. Some large and bushy specimens of *Mallotus philippensis*, *Dodonaea viscosa*, *Cassia fistula*, *Debregeasia salicifolia* and a few old and mature plants of *Phoenix humilis* were common all along the water course. The occurrence of *P. humilis* has also been reported from this area by Stewart (1967). Apart from the villages mentioned earlier some scattered Gujar huts were also noticed all over the area. The main source of income of the inhabitants, beside cultivation was dairy-farming which was also the root cause of the enormous grazing pressure on the vegetation of the area. Beyond 1240 m elevation the gradient again started rising up sharply till it ended at the highest peak at 1905 m. A few flattened patches of clear ground, the meadows, were occasionally met with. These were used as grazing pastures or resting places for the cattle and were, therefore, organically rich.

Generally speaking the site was dry, exposed and degraded being under a tremendous biotic pressure and showed an edge effect of the village (Lall and Dakwale, 1984). The site supported a thick vegetation of *Dodonaea viscosa*, *Mallotus philippensis*, *Acacia*

modesta, *Sageretia thea* var. *brandrethiana* and *Carissa opaca*. Some woody species like *Cassia fistula*, *Flacourtia indica*, *Helicteres isora* and *Olea ferruginea* were exclusively found on the south-facing aspect (Table 14) being plants fond of dry and exposed areas. *Pinus roxburghii*, however, was the dominant arborescent member of the middle and upper slopes.

These hills are privately owned and are auctioned annually for fuel wood extraction. The vegetation, therefore, is never the same at all times.

The south facing aspect is inhabited by four distinct communities occupying different slopes.

A. LOWER-MOST SLOPES

1. SPRING VEGETATION

DODONAEA-JUSTICIA-THEMEDA COMMUNITY

The *Dodonaea-Justicia-Themeda* Community started at the base level of the ravine at 550 m and stretched upto 990 m elevations. The soil was sandy loam with high values of saturation percentage, electrical conductivity, sodium, magnesium and calcium contents, sodium absorption ratio and the organic matter contents. It was also acidic (Table 12).

The slopes generally were very steep at the base. A few Gujar huts were situated at places where stream water was accessible. Wood cutting, grazing and trampling were very common.

The total number of species in the community was 51. This was the highest number of species supported by any of the south-facing communities largely because of the availability of more moisture. The number of woody plants was 20 while the rest were herbaceous (Table 19).

Among the woody species *Dodonaea viscosa* was the leading dominant and *Justicia adhatoda* as a co-dominant plant. One of the many possible reasons for these two plants attaining prominence is their non-palatability to grazing animals. *D. viscosa* becomes the target of the axe every year in September/October but stages a very quick come back due to its capability of sprouting from the cut stumps. The plant can grow and colonize steep, dry and barren soils and is immune to grazing. These characteristics explain its abundance over vast areas of highly disturbed regions (Troup, 1921). The plant was found regenerating at all the places.

J. adhatoda, locally known as Baikar, was also found regenerating profusely. It is a fast growing plant inhabiting waste places or grazed dry clayey soils with gentle slopes (Parker, 1956). It commonly grows on field ridges or lower boundaries where organic and inorganic material accumulates as a wash up by the downwardly flowing rain water. It is found ascending to 1300 m elevation in Himalayas with a wide range of annual rainfall from 500 to 1650 mm (Anonymous, 1980). The plant was found occupying waste places and grounds from where all palatable vegetation had been removed. Its unpalatability was also manifested by its presence near or around the Gujar huts or even cattle barns where it grew luxuriantly due to no fear of grazing by animals and no competition from the palatable species. Even goats avoid the plant. Adhatoda is a Tamil word meaning, what goats will not touch, (Parker, 1956). Stewart (1972) has reported it as a common plant of the sub-Himalayan tract ascending upto 1220 m in association with other heliophytic plants like *D. viscosa*, *Sageretia thea*, *Acacia modesta*, *Carissa opaca*, *Maytenus royleanus* and *Zizyphus nummularia*. All these were present on this slope. Among the rare plants were included *Grewia optiva* and *Olea ferruginea*. The last species is highly palatable (Said, 1951) and was, therefore, always found in a deformed bushy stature.

Themeda anathera took the lead from amongst the herbaceous layer and became dominant by securing the highest importance value of this stratum which was about 22% of the

total importance value. This was contributed by all the three community parameters especially the canopy coverage which was more than 44% of the total herbaceous cover. These lower slopes were comparatively more moist due to the humid climate and shade effect of the nearby ravine and were better suited to support this plant (Amarsinghe and Pemadasa, 1982).

Again, as on the lower slopes of the north facing aspect, *Gnaphalium affine* closely followed *T. anathera*. This small sized herb shows xerophytic characters and is fond of dry exposed sandy soils. In this community *G. affine* showed the highest density and frequency values (Table 19) due to its efficient reproductive mechanisms both sexual and vegetative. Its abundance on these slopes is also accounted for by the presence of a large number of open patches due to biotic interferences and the availability of suitable soil texture. *Aristida adscensionis*, another fodder grass and *Anagallis arvensis* a herb were other members of high importance value. Among the herbaceous vegetation 6 were plants of high fodder value and were a great source of attraction to the grazing animals. They included *T.anathera*, *C.dactylon*, *Aristida cyanantha*, *A.adscensionis*, *Stipa capensis* and *Cyperus niveus*. Another plant worth mentioning here was *Oxalis corniculata*. It attained a comparatively high importance value (Table 19). It grows well under the plant canopies and bushes mostly because of the protection from grazing (Jaksic and Fuentes, 1980). *O.corniculata* spreads by stolons and other underground parts and is therefore commonly met with in wet porous soils. It was found occurring in all the communities except those of the upper slopes.

Table 19 South-facing, Lowermost Slopes (spring vegetation). Phytosociological attributes of *Dodonaea-Justicia-Themedra* community

Name of Species	D	R.D.	F.	R.F.	C.C.	R.C.C.	I.V.
<i>Ajuga bracteosa</i>	0.03	0.06	0.004	0.16	0.06	0.03	0.3
<i>Amaranthus viridis</i>	0.34	0.67	0.04	1.62	1.23	0.72	3
<i>Anagallis arvensis</i>	3.56	7.00	0.13	5.25	7.16	4.16	16
<i>Arenaria serpyllifolia</i>	1.83	3.6	0.07	2.83	1.74	1.01	7
<i>Aristida adscensionis</i>	4.1	8.07	0.1	4.04	17.35	10.09	22
<i>Beorhaavia coccinea</i>	0.1	0.2	0.02	0.81	0.58	0.34	1
<i>Cannabis sativa</i>	1.45	2.85	0.07	2.83	1.74	1.01	7
<i>Chenopodium album</i>	0.08	0.16	0.01	0.40	0.19	0.11	1
<i>Conyza bonariensis</i>	1.16	2.28	0.13	5.25	2.13	1.24	9
<i>Coronopus didymus</i>	0.1	0.20	0.008	0.32	0.13	0.08	1
<i>Crotalaria medicaginea</i>	0.08	0.16	0.08	0.40	0.19	0.11	1
<i>Cynodon dactylon</i>	4.59	0.03	0.21	8.48	13.74	0.99	26
<i>Cyperus niveus</i>	0.34	0.67	0.02	0.81	2.26	1.31	3
<i>Dicliptera roxburghiana</i>	0.93	1.83	0.08	3.23	2.52	1.47	7
<i>Erodium cicutarium</i>	1.19	2.34	0.07	2.83	1.3	0.76	6
<i>Evolvulus alsinoides</i>	0.05	0.10	0.008	0.32	0.26	0.15	1
<i>Gallium aparine</i>	3.15	6.20	0.13	5.25	3.68	2.14	14
<i>Geranium ocellatum</i>	0.15	0.30	0.01	0.40	0.84	0.49	1
<i>Gnaphalium affine</i>	10.71	21.07	0.38	15.35	14.77	8.59	45
<i>Kickxia ramosissima</i>	0.15	0.30	0.02	0.81	0.26	0.15	1
<i>Lactuca dissecta</i>	1.78	3.50	0.08	3.23	3.48	2.02	9
<i>Micromeria biflora</i>	0.18	5.35	0.02	0.81	0.32	0.19	1
<i>Oxalis corniculata</i>	8.21	16.15	0.31	12.52	12.13	7.06	36
<i>Polygala abyssinica</i>	0.08	0.16	0.01	0.40	0.19	0.11	1
<i>Sida cordata</i>	0.05	0.10	0.008	0.82	0.13	0.08	1
<i>Stellaria media</i>	0.03	0.06	0.004	0.16	0.06	0.03	0.3
<i>Stipa capensis</i>	1.37	2.70	0.11	4.44	5.74	3.34	11
<i>Taraxacum officinale</i>	0.1	0.20	0.02	0.81	0.26	0.15	1

2. FALL VEGETATION

MALLOTUS-HELICTERES-OXALIS COMMUNITY

Running all along the ravine from the base of the south facing mountain and reaching upto 1000 m, the belt was occupied by *Mallotus-Helicteres-oxalis* community. The slopes were medium to steep and remained mostly under the shade of the southern mountain.

The community was floristically poor and was composed of only 21 species, 9 of which were woody (Table 20). *Mallotus philippensis*, as in all other communities of lower elevations, became the dominant arborescent member mainly due to its higher values of frequency and canopy coverage. It attained tree stature near water courses having large canopies. One such large specimen was observed at 1190 m with 105 cm CBH girth size and was 4-branched above breast height.

Helicteres isora showed the highest importance value of all the shrubby plants. This high value was contributed by the three community parameters especially the density. Almost 46% of the total density was reposed in this plant. Troup (1921) has described it a gregarious shrub coppicing well and forming a dense impenetrable growth. It yields a good fibre for which it is chopped frequently in late fall, the plant sprouting back from the cut stumps in early spring. The plant flowers in hot rainy season (Parker, 1956) and the fruits mature in December. Since the natives cut the plant before the fruits could mature or the seeds shed, very few saplings were noticed. It reproduced here only vegetatively, a fact which may largely explain its exclusive confinement in this area. Stewart (1972) has also reported this plant from Ambela.

D. viscosa was found mostly cut and chopped as the mountain had recently been auctioned for fuel wood extraction. Fresh plants were sprouting from the cut stumps which increased the density and frequency values but the canopy cover remained very low.

Other important woody plants included *J.adhatoda*, *Sageretia thea* var. *brandrethiana*, *Maytenus royleanus* and *Acacia modesta*.

Among the herbaceous flora *Oxalis corniculata* became a dominant member. It took the lead over *Aristida adscensionis*, its close competitor in this community, by having a very high value of density alone otherwise its frequency was equal to and the canopy coverage value much less than that of the latter. The high values of density of *O.corniculata* may be attributed to the cutting and lumbering effects of *D.viscosa* and other woody plants which had carved many open habitats suitable for its occurrence and growth. Infact the values of all the attributes of the community of *O.corniculata* were very low in the fall vegetation than in the spring vegetation. The reason it managed to dominate from amongst the herbaceous stature was not its efficiency to cope better with the situation. On the contrary it was rather the inefficiency of *Themeda anathera*, the herbaceous dominant of the spring vegetation, to do so and which allowed *O.corniculata* to gain the prominence. Another reason was the lesser number of plants that the fall community supported due to which *O.corniculata* gained prominence.

The rest of the herbaceous flora consisted of five forbes of high palatable value and were, therefore, a great source of attraction to the grazing cattle. Among the less important species were *Adiantum incisum*, *Dicliptera roxburghiana*, *Cannabis sativa*, *Conyza bonariensis*, *Desmodium motorium*, *Tylophora hirsuta* and *Polygonum paronychioides*.

Table 20 South-facing, Lowermost Slopes (fall vegetation). Phytosociological attributes of *Mallotus-Helicteres-Oxalis* community

Name of Species	D	R.D.	F.	R.F.	C.C.	R.C.C.	I.V.
<i>Adiantum incisum</i>	1.45	15.34	0.16	6.9	1.0	5.6	28
<i>Apluda mutica</i>	0.41	4.34	0.21	9.1	1.3	7.28	21
<i>Aristida adscensionis</i>	0.86	9.1	0.42	18.1	6.1	34.15	61
<i>Cannabis sativa</i>	0.43	4.55	0.2	8.62	1.0	5.6	19
<i>Chrysopogon serrulatus</i>	0.2	2.12	0.08	3.45	1.3	7.28	13
<i>Conyza bonariensis</i>	0.41	4.34	0.2	8.62	1.0	5.6	19
<i>Cymbopogon schoenanthus</i>	0.05	0.53	0.03	1.29	0.13	0.73	3
<i>Cynodon dactylon</i>	0.14	1.48	0.04	1.72	0.19	1.06	4
<i>Dicliptera roxburghiana</i>	0.54	5.71	0.24	10.34	1.2	6.72	23
<i>Oxalis corniculata</i>	4.15	43.92	0.42	18.1	2.1	11.76	74
<i>Polygonum paronychioides</i>	0.08	0.85	0.03	1.29	0.16	0.9	3
<i>Themeda anathera</i>	0.29	3.07	0.14	6.03	1.7	9.52	19
WOODY SPECIES							
<i>Acacia modesta</i>	0.002	0.57	0.06	1.95	0.02	0.27	3
<i>Desmodium motorium</i>	0.02	0.57	0.06	0.2	0.04	0.54	1
<i>Dodonaea viscosa</i>	0.06	17.01	0.75	24.43	0.71	9.54	51
<i>Helicteres isora</i>	0.16	45.45	1.0	32.57	3.06	41.13	119
<i>Justicia adhatoda</i>	0.05	14.2	0.38	12.38	0.64	8.6	35
<i>Mallotus philippensis</i>	0.034	9.66	0.63	20.52	2.39	32.12	62
<i>Maytenus royleanus</i>	0.006	1.70	0.13	4.23	0.04	0.54	7
<i>Sageretia thea</i> <i>brandrethiana</i>	0.04	11.36	0.12	3.91	0.58	7.8	23
<i>Tylophora hirsuta</i>	0.001	0.28	0.01	0.22	0.07	0.94	2

B. LOWER SLOPES

1. SPRING VEGETATION

MALLOTUS-DODONAEA-THEMEDA COMMUNITY

It stretched between 1040 m and 1250 m elevations. The soil was sandy loam with the lowest percentage of sand and clay and the highest percentage of silt in all the communities. The electrical conductivity and sodium contents were high while calcium and magnesium contents as well as the organic matter were medium. Its pH was acidic (Table 12). The gradient was low to medium varying between 13° and 30°.

Mallotus-Dodonaea-Thameda community supported 37 species 10 of which were woody (Table 21). The reason of having less number of species seems to lie in its low saturation percentage, low organic matter and heavy grazing and trampling pressure from the nearby villages. This community was also more exposed to sunlight than the lower one which was situated almost in the ravine and was shady and more humid.

Mallotus philippensis emerged as a dominant arborescent member of the community. This plant follows moisture gradient and was, therefore, very common and luxuriant near temporary or perennial water courses and absent from dry, exposed areas. Although it is immune to grazing it is chopped as a fire wood (Parker, 1956). The plant was found fully regenerating and all girth size classes were present at these lower and exposed slopes hinting at its higher successional status (Table 14).

Dodonaea viscosa, the dominant shrubby member, gained importance value more than twice that of *M.philippensis* due to all the three community attributes. The site was very suitable for its regeneration and growth as indicated by the presence of numerous sapling and all of the girth size classes. The plant sprouts well and quickly from the cut stumps (Parker, 1956). Its seeds are also viable and it is not grazed upon, except by goats at the time of scarcity. These

factors largely account for its prevalence in areas of its occurrence. The plant however decreased abruptly in the vicinity of village due to human interferences as manifested by the presence of numerous cut stumps. *Themeda anathera* took the lead as a dominant member from amongst the herbaceous plants closely followed by *Oxalis corniculata*. Although the density of the latter was greater and the frequency equal to that of the former, the former came to the forefront solely because of its large canopy coverage value. *T.anathera* is a rhizomatous grass of dryish soils (Bor, 1960) and can germinate quickly, like many other grasses, with the availability of water. It is a perennial grass with erect stems and extends from the subtropics to the temperate zone of Pakistan (Faruqi and Qureshi, 1987). The grass plays an important role in the balanced nitrogen circulation of the soil (Tiwari, 1984). Controlled grazing has a profound positive effect on the growth and density of *T.anathera* (Agrawal, 1984) but over-grazing decreases tillering and dry matter production (Edroma, 1985). The plant has a wide ecological amplitude climbing to 1830 m elevation (Stewart, 1972).

Oxalis corniculata is closely associated with shade and moisture (Chaghtai *et al.*, 1985a) and these were amply provided here by the thick canopies of *D.viscosa* and *M.philippensis*. Other micro-reliefs were also provided by rocks and big boulders. *M.biflora* is common from plains to 2450 m (Stewart, 1972). Among the herbaceous flora 6 were grasses which were the main source of attraction for the grazing ungulates. Plants not hit by the quadrats were *Otostegia limbata*, *Artimisia scoparia*, *Carlissa opaca*, *Cirsium arvense*, *Cassia fistula*, *Solanum anthocarpum*, *Buddleja crispa*, *Justicia adhatoda* and *Berberis lycium*. Most of these are plants of biotically disturbed and overgrazed sites (Beg, 1978).

A strong wind blew from north to south due to which the heavily grazed, and hence bushy *Olea ferruginea* and *Sageretia thea* var. *brandrethiana*, were found closely appressed to rocks on the windward sides. *Acacia modesta* was also short statured and deformed. *D.viscosa*,

however, was fully regenerating inspite of heavy cutting and a few plants, left over untouched in an inaccessible region had grown to noticeable heights. Same was the case with *M.philippensis*. Two bushy pine trees of 67 and 71 cm CBH were noticed at 1230 m elevation and a few large specimens of *Indigofera heterantha* were also seen at 1250 m elevation. Big boulders and rocks were common in the area which provided numerous micro-reliefs to the ground flora like Ferns and Bryophytes.

Table 21 South-Facing, Lower slopes (spring vegetation). Phytosociological attributes of *Mallotus-Dodonaea-Themeda* community

Name of Species	D	R.D.	F.	R.F.	C.C.	R.C.C.	I.V.
<i>Adiantum incisum</i>	1.01	2.18	0.04	1.03	2.42	0.63	4.0
<i>Amaranthus viridis</i>	0.46	0.99	0.03	0.77	1.58	0.41	2
<i>Anagallis arvensis</i>	4.21	9.08	0.14	3.61	8.95	2.34	12
<i>Aristida cyanantha</i>	1.39	3.0	0.09	2.32	20.74	5.41	11
<i>Boerhaavia coccinea</i>	0.04	0.09	0.005	0.13	0.11	0.03	0.3
<i>Bromus japonicus</i>	0.13	0.28	0.01	0.26	0.21	0.05	1
<i>Calendula arvensis</i>	0.08	0.17	0.01	0.26	0.21	0.05	1
<i>Cannabis sativa</i>	1.64	3.54	0.06	1.55	5.26	1.37	6
<i>Conyza bonariensis</i>	0.42	0.91	0.016	0.41	0.32	0.08	1
<i>Cymbopogon schoenanthus</i>	0.08	0.17	0.005	0.13	0.21	0.05	0.4
<i>Cynodon dactylon</i>	0.38	0.82	0.03	0.77	5.05	1.32	3
<i>Dicliptera roxburghiana</i>	0.67	1.44	0.04	1.03	1.89	0.49	3
<i>Gallium aparine</i>	0.51	1.1	0.03	0.77	0.53	0.14	2
<i>Geranium ocellatum</i>	0.59	1.27	0.04	1.03	2.74	0.71	3
<i>Gnaphalium affine</i>	1.68	3.62	0.09	2.32	3.05	0.8	7
<i>Inula cappa</i>	0.08	0.17	0.005	0.13	0.11	0.03	0.3
<i>Kickxia ramosissima</i>	0.08	0.17	0.01	0.26	1.26	0.33	1
<i>Koeleria gracilis</i>	0.46	0.99	0.04	1.03	2.21	0.58	3
<i>Lespedeza floribunda</i>	0.08	0.17	0.01	0.26	0.21	0.05	0.1
<i>Micromeria biflora</i>	7.07	15.24	0.11	2.84	10.32	2.69	21
<i>Oxalis corniculata</i>	9.35	20.16	0.35	9.02	23.26	6.07	35
<i>Polygonum paronychioides</i>	0.25	0.54	0.01	0.26	0.74	0.13	1
<i>Portulaca oleracea</i>	0.17	0.37	0.016	0.41	0.32	0.08	1
<i>Sida cordata</i>	1.85	3.99	0.12	3.09	4.53	1.18	8
<i>Themeda anathera</i>	7.83	16.88	0.35	9.02	86.84	22.66	49
<i>Torilis leptophylla</i>	0.08	0.17	0.01	0.26	0.21	0.05	1
<i>Vicia monantha</i>	0.04	0.09	0.005	0.13	0.21	0.05	0.3
WOODY SPECIES							
<i>Acacia modesta</i>	0.004	0.009	0.16	4.12	0.48	0.13	4
<i>Cassia fistula</i>	0.005	0.01	0.11	2.84	0.5	0.13	3
<i>Dodonaea viscosa</i>	2.73	5.89	0.97	25.0	125.7	32.8	64

Table 21 (contd)

<i>Grewia optiva</i>	0.04	0.09	0.005	0.13	0.11	0.03	0.3
<i>Indigofera heterantha</i>	0.005	0.01	0.05	1.29	1.17	0.31	2
<i>Malotus philippensis</i>	1.53	3.3	0.47	12.1	46.95	12.25	28
<i>Maytenus reyleanus</i>	0.043	0.09	0.12	3.09	2.631	0.69	4
<i>Plectranthus rugosus</i>	0.001	0.002	0.005	0.13	0.11	0.3	0.4
<i>Sageretia thea</i> var. <i>brandrethiana</i>	0.97	2.09	0.17	4.38	17.77	4.64	11
<i>Tylophora hirsuta</i>	0.08	0.18	0.01	0.26	0.95	0.25	1

2. FALL VEGETATION

MALLOTUS-DODONAEA-OXALIS COMMUNITY

Mallotus-Dodonaea-Oxalis community was composed of 12 woody and 16 herbaceous species (Table 22) and was dominated by *Mallotus philippensis*, *Dodonaea viscosa* and *Oxalis corniculata* species. The dominants from the tree and shrub were the same as those of the spring vegetation.

A thick vegetation of the dominant woody plants, interspersed with *Maytanus royleanus*, *Olea ferruginea* and *Sageretia thea* var. *brandrethiana* was noticed at about 1120 m elevation. Some plants of *Celtis australis* and *Zanthoxylum alatum* had grown into large trees in the village graveyard due to protection. *Debregeasia salicifolia* and *Rubus ellipticus* were among the rare woody plants.

Some bushy plants of *Cassia fistula* were also noticed between 900 and 1100 m showing lumbering effects. *Olea ferruginea* is a plant of dry and hot slopes (Parker, 1956) but can bear cold conditions and wild winters. However under very dry conditions, or on south facing aspects, its canopy remains very small and very little fruits are set. The plant requires loamy, sandy loam, gravelly loam or clayey loam, organically, rich non-saline and well drained soils having low water table (Khan, 1963). It is browsed by goats, camels and other animals in which case it assumes a dense shrubby form with small leaves (Troup, 1921).

Among the herbaceous flora *Oxalis corniculata* took the lead as a dominant plant replacing *Themeda anathera* of the spring vegetation.

O. corniculata avoids both complete shades and complete exposures and thrives well in a mosaic of light and shade. It grows well in moist porous soil but can withstand water stress of short durations. In December the rainfall and humidity increase while the temperature is low (Table 1). As a result of these the evapo-transpiration becomes very low. At the same time

the deciduous plants have shed their leaves allowing light to reach the soil and encouraging the luxuriant growth of *O.corniculata*. This may well be the reason for the emergence of this species as a dominant herb in 5 out of 9 fall communities (Table 2).

Other herbaceous plants of some significance were *Micromeria biflora*, *Adiantum incisum*, *Aristida adscensionis*, *Themeda anathera* and *Dicliptera roxburghiana*. Due to the inhibiting effects of *M.philippensis* (Troup, 1921) these herbs could not show their traits very well.

Table 22 South-facing, Lower slopes (fall vegetation). Phytosociological attributes of *Mallotus-Dodonaea-Oxalis* community

Name of Species	D	R.D.	F.	R.F.	C.C.	R.C.C.	I.V.
<i>Adiantum incisum</i>	5.24	10.40	0.14	5.5	4.7	4.6	21
<i>Ajuga bracteosa</i>	0.16	0.3	0.02	0.8	0.4	0.34	2
<i>Apluda mutica</i>	1.24	2.5	0.16	6.3	5.1	4.9	13
<i>Aristida adscensionis</i>	2.92	5.8	0.35	13.8	22.4	21.7	40
<i>Cannabis sativa</i>	1.92	3.8	0.2	7.9	5.1	4.9	17
<i>Conyza bonariensis</i>	2.16	4.3	0.25	9.8	5.5	5.3	20
<i>Cymbopogon schoenanthus</i>	0.2	0.4	0.03	1.2	0.5	0.5	2
<i>Cynodon dactylon</i>	0.52	1.0	0.02	0.8	0.9	0.9	3
<i>Cyperus niveus</i>	0.48	1.0	0.02	0.8	0.9	0.3	2
<i>Dicliptera roxburghiana</i>	2.64	5.3	0.26	10.2	5.6	5.4	21
<i>Micraneria biflora</i>	13.04	25.96	0.26	10.2	5.4	5.2	41
<i>Oxalis corniculata</i>	14.52	28.8	0.35	13.8	6.9	6.7	49
<i>Polygonum paronychioides</i>	1.28	2.5	0.03	1.2	3.1	3.0	7
<i>Rumex hastatus</i>	0.12	0.2	0.02	0.8	8.4	8.1	9
<i>Stipa capensis</i>	0.48	1.0	0.03	1.2	0.5	0.5	3
<i>Themeda anathera</i>	2.24	4.5	0.25	9.8	21.7	21.0	35
WOODY SPECIES							
<i>Celtis australis</i>	0.003	0.06	0.03	1.33	0.2	0.04	1
<i>Dodonaea viscosa</i>	2.35	47.8	0.76	33.6	224.95	47.3	129
<i>Justicia adhatoda</i>	0.14	2.9	0.12	5.3	1.99	0.42	9
<i>Mallotus philippensis</i>	1.69	33.3	0.61	27.00	161.45	34.0	94
<i>Maytenus royleanus</i>	0.05	3.1	0.35	15.5	24.4	5.1	24
<i>Olea ferruginea</i>	0.25	5.7	0.18	8.0	17.76	3.8	17
<i>Otostegia limbata</i>	0.003	0.6	0.01	0.44	0.4	0.01	1
<i>Periploca aphylla</i>	0.02	0.4	0.02	0.89	2.1	0.4	2
<i>Rubus ellipticus</i>	0.09	1.8	0.02	0.9	2.7	0.6	3
<i>Sageretia thea</i> var. <i>brandrethiana</i>	0.30	6.1	0.14	6.2	42.0	8.8	21
<i>Tylophora hirsuta</i>	0.07	1.4	0.09	4.0	1.9	0.4	6
<i>Zanthoxylum alatum</i>	0.003	0.6	0.05	2.2	0.04	0.01	2

C. MIDDLE SLOPES

1. SPRING VEGETATION

PINUS-DODONAEA-RUMEX COMMUNITY

From about 1240 m to 1340 m elevations, the so called edge effect of Tanoor and Tangu villages was very obvious. Grazing, trampling and above all, fuel wood extraction effects were very apparent in the area. These biotic interferences induce changes not only in the vegetation itself but also in the micro-environments which are inherent under such disturbances (Lall and Dakwale, 1984). As such this area was excluded from sampling.

The gradient beyond this zone became very steep ranging between 39°-45° although higher up it again became gentle. The soil was loamy sand and acidic. Its electrical conductivity, calcium and magnesium contents, sodium absorption ratio and percent sand were the highest of all the communities while the sodium contents were very low. Organic matter contents were quite high (Table 12). A light snow fall occurs in December and January but the snow melts away quickly.

Pinus-Dodonaea-Rumex community was dominated by *Pinus roxburghii*, *Dodonaea viscosa* and *Rumex hastatus*. Out of the spring communities this one possessed the lowest number of species represented by 9 woody and 14 herbaceous plants (Table 23). This was not only due to the biotic interferences referred to above but might be related to edaphic factors including high concentration of salts which have been shown to be of considerable importance in determining the pattern and composition of vegetation of an area (Kayani *et al.*, 1984 b).

Pinus roxburghii took a lead as a dominant member of the arboreal vegetation. It subdued *Mallotus philippensis*, another tree member, largely due to its high value of canopy cover. *P. roxburghii* was represented by relatively few and younger plants which were not

uniformly distributed. This is manifested by comparatively lower values of the three attributes than those of the upper slope.

Among the shrubby members, *Dodonaea viscosa* emerged as a prominence. There were a large number of individuals of this plant which were evenly distributed, a fact supported by the highest values of density and frequency among all the woody species. It was also fully regenerating as shown by the presence of numerous saplings. Other woody species of lesser importance value were *Sageretia thea* var. *brandrethiana*, *Berberis lycium*, *Carissa opaca* and *Celtis australis*. All these showed effects of biotic interferences

From amongst the herbaceous plants *Rumex hastatus* came into prominence largely because of relatively high value of canopy cover. It is a small erect plant of sub-Himalayan tract ascending upto or beyond about 2000 m but is more common at the base of the mountain, banks of streams, cracks of walls or among loose rocks (Stewart, 1972). It quickly colonizes dry stream beds, freshly made embankments and mineral soils (Parker, 1956). In this community it was abundantly present in the vicinity of clearings made by the inhabitants, particularly in the stone heaps or cracks of stone walls where the winged fruits of the plant are easily deposited by wind. In an experiment, Welch (1985) found numerous germinated seedlings of *Rumex acetosella* (an associated species) in cattle dung. The abundance of *R. hastatus* here in the grazed areas may well be associated with the presence of cattle dung. The plant is a perennial with rhizomatous base which helps in rapid colonization if it loses its apical dominance (Fowler, 1982). It flourishes well in spring but old and mature individuals may occur in the fall.

Other herbaceous plants of some importance were *Cannabis sativa*, *Cyperus niveus*, *Ceterarch dalhousiae*, *Micromeria biflora*, *Oxalis corniculata*, *Cymbopogon schoenanthus* and *Oenothera rosea*. Among the rare plants *Ajuga bracteosa*, *Saromatium guttatum*, *Zizyphus nummularia*, *Lantana camara* and a big tree of *Phoenix humilis* were included.

Table 23 South-facing, Middle slopes (spring vegetation). Phytosociological attributes of *Pinus-Dodonaea-Rumex* community

Name of Species	D	R.D.	F.	R.F.	C.C.	R.C.C.	I.V.
<i>Adiantum incisum</i>	1.8	4.60	0.08	4.2	1.5	1.04	10
<i>Cannabis sativa</i>	3.67	9.5	0.3	15.8	19.0	13.2	38
<i>Ceterarch dalhousiae</i>	5.6	14.4	0.18	9.5	13.3	9.3	33
<i>Cymbopogon schoenanthus</i>	1.73	4.5	0.15	7.9	11.5	8.0	20
<i>Cyperus niveus</i>	5.33	13.7	0.23	12.1	8.5	5.9	32
<i>Dicliptera roxburghiana</i>	0.27	0.7	0.03	1.6	0.67	0.47	3
<i>Gnaphalium affine</i>	1.67	4.3	0.07	2.7	1.3	0.9	9
<i>Imperata cylindrica</i>	0.53	1.4	0.04	2.1	0.83	0.6	4
<i>Micromeria biflora</i>	4.33	11.2	0.12	6.3	4.0	2.8	20
<i>Oenothera rosea</i>	2.13	5.5	0.15	7.9	3.83	2.7	16
<i>Oxalis corniculata</i>	4.33	11.12	0.09	4.7	4.3	3.0	19
<i>Phalaris minor</i>	2.33	6.8	0.08	4.2	4.2	2.9	14
<i>Rumex hastatus</i>	3.4	8.8	0.28	14.7	64.7	45.0	68
<i>Themeda anathera</i>	1.4	3.6	0.07	3.7	5.5	3.8	11
WOODY SPECIES							
<i>Berberis lycium</i>	0.004	2.2	0.08	4.2	0.17	1.2	8
<i>Carissa opaca</i>	0.002	1.1	0.08	4.2	0.22	1.5	7
<i>Celtis australis</i>	0.002	1.1	0.08	4.2	0.03	0.2	6
<i>Dodonaea viscosa</i>	0.084	46.2	0.47	25.1	4.08	28.2	100
<i>Indigofera heterantha</i>	0.002	1.1	0.05	2.7	0.08	0.6	4
<i>Mallotus philippensis</i>	0.038	20.9	0.42	23.5	2.62	18.2	62
<i>Pinus roxburghii</i>	0.04	22.0	0.44	23.5	7.03	48.6	94
<i>Sageretia thea</i> var. <i>brandrethiana</i>	0.01	5.5	0.25	13.4	0.22	1.5	20
<i>Tylophora hirsuta</i>	0.002	1.1	0.04	2.1	0.08	0.5	4

2. FALL VEGETATION

PINUS-DODONAEA-MICROMERIA COMMUNITY

The community dominated by *Pinus roxburghii*, *Dodonaea viscosa* and *Micromeria biflora*, was floristically poor supporting only 22 species, 10 of which were woody and the rest herbaceous (Table 24).

The soil was highly degraded. Cultivated and fallow fields were common in which erosion had played its role. Proper terracing of the field was not done. Large stones or rock pieces were loosely heaped around the fields for the purpose but were unable to check the flow of rain water and the consequent erosion.

The community differed from the corresponding spring community in the herbaceous dominant member only when *M.biflora* replaced *Rumex hastatus*.

M.biflora was represented by a large number of plants which were clustered at places. This probably hints at the mosaic of microhabitats prevailing on the site. Trailing behind were *Oxalis corniculata* and *R.hastatus*. The latter, though a perennial plant flourishing more in spring rather than fall, was represented by the remnants of the spring vegetation and gained some importance solely due to a high canopy coverage value.

Other herbs of relatively less importance were *Conyza bonariensis*, *Aristida cyanantha*, *Adiantum incisum*, *Cannabis sativa* and *Dicliptera roxburghiana*.

Some woody plants, beside *P.roxburghii*, *Mallotus philippensis* and *D.viscosa*, included *Berberis lycium*, *Debregeasia salicifolia*, *Olea ferruginea*, *Rubus ellipticus*, *Sageretia thea* var. *brandrethiana* and *Zizyphus oxyphylla*. All these were heavily lumbered, grazed and deformed.

Among the rare plants *Desmostachya bipinnata*, *Celtis australis* and *Carissa opaca* were included.

Table 24 South-facing, Middle slopes (fall vegetation). Phytosociological attributes of
Pinus-Dodonaea-Micromeria community

Name of Species	D	R.D.	F.	R.F.	C.C.	R.C.C.	I.V.
<i>Adiantum incisum</i>	0.9	8.75	0.09	5.29	0.95	7.69	23
<i>Ajuga bracteosa</i>	0.3	2.92	0.07	4.12	0.3	2.43	9
<i>Aristida cyanantha</i>	0.28	2.72	0.13	7.65	1.65	13.36	24
<i>Cannabis sativa</i>	0.24	2.33	0.12	7.06	0.6	4.86	14
<i>Conyza bonariensis</i>	0.7	6.81	0.24	14.12	1.2	9.72	30
<i>Cyperus niveus</i>	1.0	9.73	0.11	6.47	0.55	4.45	21
<i>Dicliptera roxburghiana</i>	0.3	2.92	0.15	8.82	0.75	6.07	18
<i>Micromeria biflora</i>	3.44	33.46	0.29	17.06	1.45	11.74	62
<i>Oxalis corniculata</i>	2.34	22.46	0.23	13.53	1.15	9.31	45
<i>Polygonum paronychioides</i>	0.08	0.78	0.04	2.35	0.2	1.62	5
<i>Rumex hastatus</i>	0.48	4.67	0.13	7.65	2.75	22.27	34
<i>Themeda anathera</i>	0.04	0.39	0.02	1.18	0.35	2.83	4
WOODY SPECIES							
<i>Berberis lycium</i>	0.025	5.83	0.7	16.28	5.14	2.96	25
<i>Debregeasia salicifolia</i>	0.005	1.17	0.2	4.65	1.04	0.64	6
<i>Dodonaea viscosa</i>	0.170	39.63	0.9	20.93	34.62	19.94	81
<i>Mallotus philippensis</i>	0.135	31.57	0.8	18.8	28.48	18.23	66
<i>Olea ferruginea</i>	0.015	3.5	0.6	13.95	6.00	3.46	21
<i>Pinus roxburghii</i>	0.068	15.85	0.8	18.6	92.96	53.55	88
<i>Rubus ellipticus</i>	0.003	0.7	0.1	2.32	0.28	0.16	3
<i>Sageretia thea</i> var. <i>brandrethiana</i> .	0.005	1.17	0.1	2.32	1.39	0.80	4
<i>Tylophora hirsuta</i>	0.003	0.7	0.09	2.1	0.45	0.26	3
<i>Zizyphus oxyphylla</i>	0.003	0.7	0.1	2.32	0.69	0.4	3

D. UPPER SLOPES

1. SPRING VEGETATION

PINUS-BERBERIS-GERANIUM COMMUNITY

This community occupied the uppermost slopes ranging between 1540 m and 1905 m elevation culminating at the highest peak called Gishar Sar and was dominated by *Pinus roxburghii*, *Berberis lycium* and *Geranium ocellatum* community.

The slopes were gentle to steep. The soil was sandy loam with the lowest values of saturation percentage, electrical conductivity, calcium contents and sodium absorption ratio. Organic matter contents were very high due to the accumulation of thick pad of pine litter while the magnesium contents were also very high. The soil was acidic (Table 12).

The community consisted of 9 woody and 30 herbaceous plants (Table 25). *Pinus roxburghii* took the lead from amongst the arborescent stratum. All the three community attributes contributed towards it. About 63% of the importance value and more than 97% of the total shade cast by the woody species was contributed by *P. roxburghii* alone.

Pine zone started at about 1500 m elevation. The biotic effect on the marginal plants was quite apparent in the form of many bushy deformed and lumbered pine trees. As the pine forest thickened higher up the layer of pine needles went on increasing, sometimes upto 20 cm deep. Pines were fully regenerating as manifested by the presence of numerous saplings. Plants of all girth size classes ranging between 15 cm to 180 cm CBH were represented. However the maximum concentration was between 30 cm and 100-120 cm CBH (Table 17). The steep slopes with rounded spurs, loamy sand and porous soil, high organic matter and high monsoon rainfalls are responsible for the reproduction, germination and favourable growth of *P. roxburghii* (Troup, 1921; and Parker, 1956).

The total number of pine trees per hectare was, however, the lowest as compared to the north and east facing aspects (Table 17). Beside the aspect effect and the high biotic interference, this low number of plants may be attributed to the absence of understorey vegetation, bushes or grass tussocks which, otherwise, could have acted as catchment places for the falling pine seeds (Troup, 1921). The presence of a thick pad of pine needles proved to be an added hinderance to the germination of seeds (Parker, 1956). The presence of a lesser number of pine saplings speaks of an immense increase in the biotic interference in the recent past, a fact which is further supported by the presence of a number of lumbered and deformed trees, particularly on the outskirts of the forest. *Berberis lycium* a deciduous spring shrub, appeared as a dominant representative of the shrub layer but only with less than one fourth importance value as that of *P. roxburghii*. It was because of low value of density and very low value of canopy coverage. *B. lycium* is a common plant of steep open hillsides from 1000-2000 m (Parker, 1956; and Stewart, 1958). It is not valued as a fodder plant but is extracted as a fuel wood or for its roots which bear medical value. The plant may attain small bushy stature on loamy and less steep soils. One or two thick impenetrable thickets of such large size plants of *B. lycium* were encountered at the base and near the top of the highest peak. Some of these plants were about 4 m high with about 20 cm CBH. Mixed with these, two or three *Quercus incana* trees with 110-130 cm CBH were encountered.

Other associated woody species were *Sageretia thea* var. *brandrethiana*, *Dodonaea viscosa*, *Myrsine africana* *Clematis graveolens*, *Mallotus philippensis*, *Rubus ellipticus* and *Olea ferruginea*. The last species, though with very little importance value, is worth elucidation here. Only 8 specimens of this plant, all less than 5 cm CBH were encountered which were all heavily cut and grazed. They were thus bushy and appressed to rocks. *O. ferruginea* was

not encountered on the north facing aspect, whereas only 7 specimens of 5-10 cm CBH were met with on the east facing aspect (Table 17).

Similarly the importance values of *M.philippensis* and *D.viscosa* were drastically reduced in this community probably due to more shady situation prevailing here than the lower slopes. Their occurrence was also adversely affected by the presence of thick pine litter which hindered seed germination.

Geranium ocellatum became dominant from amongst the herbaceous stature. It is a plant of cool, wet and shady places of high altitudes. All the three community attributes contributed towards its dominance in this community.

Other herbaceous plants of some importance value were *Themeda anathera*, *Oxalis corniculata* and *Micromeria biflora*.

Among the rare plants were included *Otostegia limbata*, *Heliotropium europaeum*, *Delphinium uncinatum*, *Gerbera gossypina*, *Verbascum thapsus*, *Torilis leptophylla*, *Erigeron alpinus*, *Buddleja crispa*, *Gagea elegans*, *Cheilanthes pteridioides*, *Periploca aphylla*, *Ficus palmata*, *Quercus incana* and *Q.ilex*.

Numerous small and large specimens of *Phoenix humilis* were also found scattered in the area. Earlier workers (Troup, 1921; Parker, 1956; and Stewart, 1972) have also reported it from this area. The plant was most common along the water courses.

Table 25 South-facing, Upper slopes (spring vegetation). Phytosociological attributes of *Pinus-Berberis-Geranium* community

Name of Species	D	R.D.	F.	R.F.	C.C.	R.C.C.	I.V.
<i>Adiantum incisum</i>	2.32	6.1	0.04	2.4	3.4	3.4	12
<i>Ajuga bracteosa</i>	0.76	2.0	0.05	3.0	1.5	1.5	7
<i>Anagallis arvensis</i>	1.05	2.8	0.03	1.8	1.6	1.6	6
<i>Arenaria serpyllifolia</i>	1.05	2.8	0.05	3.0	2.0	2.0	8
<i>Cannabis sativa</i>	0.13	0.3	0.02	1.2	0.3	0.3	2
<i>Cheilanthes pteridioides</i>	0.17	0.4	0.01	0.6	0.2	0.2	1
<i>Conyza bonariensis</i>	0.25	0.7	0.02	1.2	0.3	0.3	2
<i>Cynodon dactylon</i>	0.34	0.9	0.02	1.2	1.5	1.5	4
<i>Delphinium uncinatum</i>	0.04	0.1	0.005	0.3	0.1	0.1	1
<i>Dicliptera roxburghiana</i>	1.0	2.6	0.09	5.5	3.5	3.5	12
<i>Erigeron alpinus</i>	0.08	0.2	0.01	0.6	0.2	0.2	1
<i>Erodium cicutarium</i>	0.59	1.5	0.04	2.4	1.3	1.3	5
<i>Filago pyramidalata</i>	1.0	2.6	0.01	0.6	1.3	1.3	5
<i>Gallium aparine</i>	2.02	5.3	0.08	4.8	2.7	2.7	13
<i>Geranium ocellatum</i>	6.91	18.1	0.32	19.4	20.8	20.6	58
<i>Gerbera gossypina</i>	0.29	0.8	0.04	2.4	0.7	0.7	4
<i>Grewia optiva</i>	0.13	0.3	0.005	0.3	1.6	1.6	2
<i>Medicago orbicularis</i>	0.17	0.4	0.005	0.3	0.1	0.1	1
<i>Micromeria biflora</i>	4.55	11.9	0.13	7.9	6.1	6.0	26
<i>Oenothera rosea</i>	3.49	9.1	0.08	4.8	6.3	6.2	20
<i>Oxalis corniculata</i>	4.0	10.5	0.13	7.9	8.5	8.4	27
<i>Phalaris minor</i>	0.25	0.7	0.005	0.3	0.6	0.6	2
<i>Plantago lanceolata</i>	0.59	1.5	0.02	1.2	0.3	0.3	3
<i>Stipa capensis</i>	1.26	3.3	0.09	5.5	4.4	4.4	13
<i>Themeda anathera</i>	2.99	7.8	0.13	7.9	22.7	22.5	38
<i>Torilis leptophylla</i>	0.21	0.6	0.01	0.6	0.2	0.2	1
<i>Verbascum thapsus</i>	0.08	0.2	0.01	0.6	0.2	0.2	1
<i>Veronica arvensis</i>	0.88	2.3	0.04	2.4	1.3	1.3	6
<i>Vicia monantha</i>	0.21	0.6	0.02	1.2	0.4	0.4	2
<i>Viola ceneszens</i>	0.88	2.3	0.08	4.8	2.0	2.0	9

WOODY SPECIES

<i>Berberis lycium</i>	0.02	18.2	0.58	21.6	0.63	1.2	41
<i>Clematis graveolens</i>	0.005	4.5	0.21	7.8	0.08	0.2	13
<i>Dodonaea viscosa</i>	0.008	7.3	0.32	11.9	0.33	0.6	20
<i>Indigofera heterantha</i>	0.008	7.3	0.21	7.8	0.12	0.2	15
<i>Mallotus philippensis</i>	0.001	0.9	0.05	1.9	0.04	0.1	3
<i>Olea ferruginea</i>	0.001	0.9	0.05	1.9	0.05	0.1	3
<i>Pinus roxburghii</i>	0.06	54.6	1.0	37.3	49.74	97.4	189
<i>Plectranthus rugosus</i>	0.001	0.9	0.02	0.9	0.06	0.12	3
<i>Rubus ellipticus</i>	0.007	6.3	0.26	9.7	0.06	0.12	16

2. FALL VEGETATION

PINUS-BERBERIS-OXALIS COMMUNITY

The *Pinus-Berberis-Oxalis* community supported 28 different species, 9 of which were woody (Table 26).

The arborescent and shrubby dominant numbers were the same as those of the spring community. *Oxalis corniculata*, however, replaced *Geranium ocellatum* as a dominant from the herbaceous layer. All the three community attributes contributed towards this. *Cannabis sativa*, *Ceterarch dalhousiae* and *Micromeria biflora* were among other herbaceous plants of some standings in this community.

Among rare herbaceous plants were included *Verbascum thapsus*, *Androsac rotundifolia*, and *Conyza bonariensis*.

Table 26 South-facing, Upper slopes (fall vegetation). Phytosociological attributes of *Pinus-Berberis-Oxalis* community

Name of Species	D	R.D.	F.	R.F.	C.C.	R.C.C.	I.V.
<i>Ajuga bracteosa</i>	1.01	4.5	0.23	9.0	2.18	4.7	18
<i>Androsac rotundifolia</i>	0.02	0.1	0.006	0.2	0.06	0.1	1
<i>Apluda mutica</i>	0.49	2.2	0.11	4.3	1.29	2.8	9
<i>Aristida cyanantha</i>	0.54	2.4	0.07	2.7	0.94	2.0	7
<i>Bergenia himalaica</i>	0.33	1.5	0.06	2.4	0.53	1.1	5
<i>Cannabis sativa</i>	1.46	6.5	0.31	12.1	7.59	16.4	35
<i>Ceterarch dalhousiae</i>	3.13	14.0	0.28	11.0	2.88	6.2	31
<i>Conyza bonariensis</i>	0.05	0.2	0.01	0.4	0.12	0.3	1
<i>Cymbopogon schoenanthus</i>	0.45	2.0	0.11	4.3	3.82	8.3	15
<i>Cynodon dactylon</i>	0.07	0.3	0.02	0.8	0.18	0.4	2
<i>Dicliptera roxburghiana</i>	0.73	3.3	0.19	7.4	1.82	3.9	15
<i>Geranium ocellatum</i>	0.99	4.4	0.21	8.2	2.0	4.3	17
<i>Micromeria biflora</i>	3.6	16.1	0.23	9.0	2.47	5.3	30
<i>Oenothera rosea</i>	0.56	2.5	0.15	5.9	1.41	3.0	11
<i>Oxalis corniculata</i>	7.55	33.7	0.39	15.26	9.18	19.8	69
<i>Rumex hastatus</i>	0.40	1.8	0.06	2.3	6.65	14.4	19
<i>Taraxacum officinale</i>	0.50	2.2	0.01	0.4	0.12	0.3	3
<i>Themeda anathera</i>	0.42	1.9	0.09	3.5	1.71	3.7	9
<i>Verbascum thapsus</i>	0.05	0.2	0.01	0.4	0.12	0.3	1
WOODY SPECIES							
<i>Berberis lycium</i>	0.06	18.4	0.37	14.3	1.27	1.1	34
<i>Dodonaea viscosa</i>	0.06	18.35	0.25	9.7	0.30	0.3	28
<i>Indigofera heterantha</i>	0.02	6.1	0.31	12.0	0.54	0.5	19
<i>Mallotus philippensis</i>	0.005	1.5	0.13	5.0	0.12	0.1	7
<i>Olea ferruginea</i>	0.01	3.1	0.13	5.0	0.10	0.1	8
<i>Otostegia limbata</i>	0.001	0.3	0.01	0.39	0.12	0.12	1
<i>Pinus roxburghii</i>	0.14	42.8	1.00	38.76	109.24	96.2	178
<i>Quercus incana</i>	0.002	0.6	0.06	2.3	1.4	1.2	4
<i>Rubus ellipticus</i>	0.03	9.2	0.33	12.8	0.56	0.5	22

IV. EAST FACING ASPECT

The mountain, on the top of which Gishar Sar is situated, turns towards the north through about 90° and carves this aspect. It starts at 725 m elevation and ends at Gishar Sar with 1905 m from the east. As opposed to the south facing aspect, this aspect was cooler, greener, more humid and less exposed. A few Gujar huts were also present here near a water stream. Goats and other animals were common.

East facing aspect supported three communities. The basal and top communities had the same dominant members as those on the corresponding south facing elevation while the middle communities of the two aspects differed only in the third dominant member from the herbaceous stratum. This supports the findings of Armesto and Martinez (1978) that south facing aspects are floristically similar to east and west facing aspects. This aspect, like others, was also heavily disturbed. Lumbering and fuel wood extraction was very common. Mule tracks started from the peaks and, spreading in a finger like manner entered different small villages situated at the base of the mountain along the metalled road. Cultivated fields, however, were only a few and were mostly confined to the middle slope.

A. LOWER SLOPES

1. SPRING VEGETATION

MALLLOTUS-DODONAEA-THEMEDA COMMUNITY

Mallotus-Dodonaea-Themeda community stretched between 725 m and 1160 m elevation. The slopes were mostly steep ranging between 16°-39° and the temperature between 28°-35°C in the month of April. The soil was sandy loam with a high percentage of sand and was poorly developed. Its chemical analysis revealed low values of saturation percentage, electrical conductivity and calcium and magnesium contents. It was slightly acidic with the lowest organic matter contents (Table 12). Grazing and other biotic disturbances were very common. This community supported 9 woody and 17 herbaceous plants (Table 27). The community was dominated by *Mallotus philippensis*, *Dodonaea viscosa* and *Themeda anathera*.

M.philippensis took the lead from amongst the arborescent species by dint of having high values of the community attributes particularly the canopy cover. About 47% of the total shade cast by all the woody plants was contributed by this species alone. *M.philippensis* is a shade and moisture loving plant and the presence of considerable amount of spring water on this aspect makes it more suitable for the growth of this plant.

Dodonaea viscosa became dominant from the shrubby layer due to having very high values of the three community attributes. It was abundantly regenerating as manifested by the presence of a large number of saplings. Trailing behind it was another woody plant, *Justicia adhatoda*, which was also found regenerating. Both these are plants of poor dryish soils, waste places or hedges. The former avoids traps and favours sandy soils (Troup, 1921) while the latter is fond of clayey soils (Parker, 1956, and Anonymous, 1980). Both of them, especially *J.adhatoda*, escape grazing. All these characteristics contributed for their presence and growth

on these heavily grazed soils. *J.adhatoda* ascends to about 1200 m while *D.viscosa* may find its way through pine zone to about 2000 m on bare dry soils (Stewart, 1972).

Other woody plants commonly met with were heavily grazed or lumbered xerophytes. They included *Sageretia thea* var. *brandrethiana*, *Acacia modesta*, *Zizyphus nummularia*, *Z. oxyphylla* and *Grewia optiva*. These plants were deformed and bushy due to overgrazing in the area (Beg, 1978). *Themeda anathera*, the herbaceous dominant of the community, is an important fodder grass of the dryish soils (Bor, 1960) ascending upto 1830 m (Stewart, 1972). It is a densely tufted perennial grass with creeping rhizomes and is highly palatable (Cope, 1982). Rare herbaceous plants were *Tribulus terrestris*, *Achyranthus aspera* and *Oxalis corniculata*.

Table 27 East-facing, Lower slopes (spring vegetation). Phytosociological attributes of *Mallotus-Dodonaea-Themeda* community

Name of Species	D	R.D.	F.	R.F.	C.C.	R.C.C.	I.V.
<i>Achyranthus aspera</i>	0.01	0.6	0.04	1.7	0.02	0.1	2.0
<i>Adiantum incisum</i>	0.05	2.9	0.19	8.0	0.03	0.2	11.0
<i>Amaranthus viridis</i>	0.01	0.6	0.04	1.7	0.02	0.1	2.0
<i>Anagallis arvensis</i>	0.04	2.3	0.08	3.4	0.05	0.3	6.0
<i>Aristida adscensionis</i>	0.05	2.9	0.13	5.5	0.75	5.2	14.0
<i>Boerhaavia coccinea</i>	0.001	0.06	0.005	0.2	0.003	0.02	0.3
<i>Cannabis sativa</i>	0.01	0.6	0.05	2.1	0.1	0.7	3.0
<i>Cynodon dactylon</i>	0.07	4.0	0.09	3.8	0.5	3.5	11.0
<i>Gnaphalium affine</i>	0.11	6.3	0.26	10.9	0.28	1.9	19.0
<i>Inula cappa</i>	0.04	2.3	0.1	4.2	0.11	0.8	7.0
<i>Kochia indica</i>	0.001	0.06	0.005	0.2	0.003	0.02	0.3
<i>Koeleria gracilis</i>	0.008	0.5	0.03	1.3	0.02	0.1	2.0
<i>Micromeria biflora</i>	0.01	0.6	0.02	0.8	0.01	0.7	2
<i>Oxalis corniculata</i>	0.23	13.2	0.24	10.1	0.26	1.8	25.0
<i>Themeda anathera</i>	0.17	9.7	0.26	10.9	2.45	17.1	38.0
<i>Tribulus terrestris</i>	0.009	0.5	0.04	1.7	0.02	0.1	2.0
WOODY SPECIES							
<i>Acacia modesta</i>	0.022	1.3	0.04	1.7	0.48	3.3	6.0
<i>Dodonaea viscosa</i>	0.16	9.2	0.29	12.2	4.81	33.5	55
<i>Grewia optiva</i>	0.003	0.2	0.01	0.4	0.11	0.8	1.0
<i>Justicia adhatoda</i>	0.14	8.0	0.27	11.3	2.96	20.6	40
<i>Mallotus philippensis</i>	0.097	5.6	0.26	10.9	6.79	47.3	64
<i>Sageretia thea</i> var. <i>brandrethiana</i>	0.03	1.7	0.09	3.8	0.86	6.0	12
<i>Sida cordata</i>	0.001	0.07	0.01	0.4	0.02	0.2	1
<i>Tylophora hirsuta</i>	0.001	0.07	0.01	0.4	0.02	0.2	1
<i>Xanthium strumarium</i>	0.02	1.3	0.004	0.2	0.27	1.9	3
<i>Ziziphus oxyphylla</i>	0.003	0.2	0.01	0.4	0.04	0.3	1

2. FALL VEGETATION

MALLOTUS-DODONAEA-ARISTIDA COMMUNITY

In *Mallotus-Dodonaea-Aristida* Community the woody dominants were the same as those of the spring community. Only the herbaceous member was replaced by *Aristida cyanantha* (Table 28). All the three community attributes of *Aristida cyanantha*, particularly the frequency and canopy cover values, highly contributed towards its success. It contributed about 41 % of the total herbaceous cover. *A. cyanantha* is a densely tufted robust perennial grass (Cope, 1982) which appears soon after rains. Species of *Aristida* (*A. funiculata*) favours sloping loamy or silty clay and non saline soils (Hussain, 1964). *A. cyanantha* grows well in dry places or stony beds of dried up streams (Bor, 1960) or rocky banks (Stewart, 1972). When the plant dies in winter the root suckers remain buried in the soil which quickly sprout in favourable season to form large clumps. Grazing animals favour this plant when young but avoid the mature plants once the tough and sharply pointed awns appear

These slopes were steep rocky mostly inaccessible and with the lowest amount of organic matter. The inaccessibility protected the grass from grazing and the absence of organic litter also helped in the germination of the seeds. These factors may largely explain the dominance of *A. cyanantha* on these slopes.

Next in order of descending importance value were *Cynodon dactylon* and *Oxalis corniculata*. The former was mostly helped by density and canopy cover and the latter by density and, to some extent the frequency, to capture positions of importance.

Rare plants included *Lespedeza floribunda*, *Solanum nigrum* and *Adiantum incisum*.

Table 28 East-facing, Lower slopes (fall vegetation), Phytosociological attributes of
Mallotus-dodonaea-aristida community

Name of Species	D	R.D	F	R.F	C.C	R.C.C	I.V
<i>Achyranthus aspera</i>	0.14	1.7	0.05	2.4	0.61	2.1	6
<i>Adiantum incisum</i>	0.24	2.9	0.04	1.9	0.18	0.6	5
<i>Apluda mutica</i> var. <i>aristata</i>	0.27	3.3	1.14	6.6	0.86	3.0	13
<i>Aristida cyanantha</i>	1.03	12.5	0.39	18.5	40.7	40.7	72
<i>Bidens chinensis</i>	0.19	2.3	0.09	4.3	0.43	1.5	8
<i>Boerhaavia coccinea</i>	0.11	1.3	0.06	2.8	0.29	1.0	5
<i>Cannabis sativa</i>	0.41	5.0	0.14	6.6	1.07	3.7	15
<i>Ceterarch dalhousiae</i>	0.51	6.2	0.09	4.3	0.44	1.5	12
<i>Conyza bonariensis</i>	0.77	9.3	0.14	6.6	1.14	4.0	20
<i>Cynodon dactylon</i>	1.81	22.0	0.21	10.0	6.86	23.9	56
<i>Erigeron alpinus</i>	0.19	2.3	0.09	4.3	0.46	1.6	8
<i>Euphorbia pilulifera</i> var. <i>hirta</i> .	0.07	0.8	0.04	1.9	0.18	0.6	3
<i>Lespedeza floribunda</i>	0.13	1.6	0.06	2.8	0.32	1.1	6
<i>Oxalis corniculata</i>	1.46	17.7	0.21	10.0	0.96	3.3	31
<i>Polygonum paronychioides</i>	0.13	1.6	0.06	2.8	0.32	1.1	6
<i>Solanum nigrum</i>	0.06	0.7	0.03	1.4	0.14	0.5	3
<i>Themeda anathera</i>	0.2	2.4	0.1	4.7	1.75	6.1	13
WOODY SPECIES							
<i>Dodonaea viscosa</i>	0.19	36.3	0.71	26.2	7.25	30.4	93
<i>Justicia adhatoda</i>	0.12	22.94	0.43	15.9	2.79	11.7	51
<i>Mallotus philippensis</i>	0.18	34.4	0.86	31.7	12.16	51.0	117
<i>Maytenus royleanus</i>	0.002	0.38	0.07	2.6	0.03	0.13	3
<i>Olea ferruginea</i>	0.004	0.76	0.14	5.2	0.03	0.13	6
<i>Sageretia thea</i> var. <i>brandrethiana</i>	0.007	1.34	0.21	7.7	0.36	1.5	11
<i>Sida cordata</i>	0.002	0.38	0.03	1.4	0.03	0.13	2
<i>Tylophora hirsuta</i>	0.002	0.38	0.07	2.6	0.03	0.13	3
<i>Ziziphus oxyphylla</i>	0.02	3.82	0.29	10.7	1.2	5.0	20

B. MIDDLE SLOPES

1. SPRING VEGETATION

PINUS-DODONAEA-OXALIS COMMUNITY

Pinus-Dodonaea-Oxalis community occupied a belt between 1180 m and 1550 m elevation. The slopes became steeper ranging between 25°-40° and the temperature ranged between 33° and 35° C. The soil was sandy loam having the lowest organic matter of all the sites and was slightly acidic. Its electrical conductivity, sodium, calcium and magnesium contents were also very low. However, the sodium absorption ratio was on the higher side of the scale (Table 10). At about 1200 m elevation a few Gujar huts were located beyond which the pine forest began thickening accompanied by an increase in pine needles and other organic matter.

There were a total of 33 species, 14 of which were woody and the rest herbaceous (Table 29). Dominant among the trees was *Pinus roxburghii*. It started appearing at 1180 m. In the beginning the trees were few, scattered and small sized. Above 1200 m elevation they started increasing not only in girth but also in density and frequency. A well drained soil and moderate to steep gradients favoured its occurrence and growth on these slopes (Parker, 1956). The enhanced values of all the three community parameters contributed to the very high importance value of *P. roxburghii*. The presence of all girth size classes between 15-220 cm CBH indicate that the plant was well regenerating in the recent past. The density of pine trees were also high on this than on the other two aspects already discussed. In fact the density of *P. roxburghii* in this community was more than 3 times that in the *Pinus-Dodonaea-Rumex* community on the corresponding elevation on the South facing aspect (Table 23). They were, however, dwindling due to being heavily lumbered for timber, fuel-wood and even charcoal. Most of the big trees were found with their pilots cult off which ultimately result in the drying up of the plants.

The co-dominant member from the shrub layer was *Dodonaea viscosa*. It shot up into prominence by dint of its second highest values of density and frequency. Most of the plants were young, less than 15 cm CBH and hence with a low canopy cover. The plants were bushy as they were sprouting from old cut stumps. Many freshly cut plants were also frequently encountered.

Mallotus philippensis was also found heavily cut. Its frequency and density were therefore low and could not come to the forefront. *Indigofera heterantha* was present above 1350 m elevation. It is a common shrub of the hills at this elevation and is gregarious on open grassy hillsides or as an under growth in dry forest avoiding moist shady ravines. The plant is of considerable help in affording shelter to the seedlings (Parker, 1956).

Berberis lycium also appeared at the above elevation but was neither as abundant nor as frequent as *I. heterantha*. It helps in soil binding and checking erosion (Parker, 1956). Both these plants have been reported invading degraded open spaces (Beg, 1978).

Sageretia thea var. *brandrethiana*, *Maytenus royleanus*, *Carissa opaca*, *Butea monosperma* and *Debregeasia salicifolia* were other woody plants but of lesser importance.

Oxalis corniculata cropped up as the dominant herbaceous plant due to very high values of the three community attributes. The weed grows almost in pure patches in moist shady places or along water courses (Chaghtai and Khattak, 1983) and has a strong allelopathic effect, especially the dried leaves (Chaghtai *et al.*, 1985a). It is a common herbaceous plant of the tropical dry deciduous forest of sub-tropical forests (Beg and Khan, 1974). The plant reproduces well both vegetatively and through seeds. Being protected by the thickets it mostly avoids grazing (Jaksic and Fuentes, 1980) thus gaining high importance values in many, if not all, communities.

Aristida cyanantha, *Cannabis sativa*, *Colebrookia oppositifolia*, *Micromeria biflora*, *Themeda anathera* and *Viola canescens* were among other herbs worth mentioning. The

last mentioned species was particularly abundant on higher elevations in wet woods or open meadows. It propagates through its rhizomes and its growing period is between May and June (Solbrig *et al.*, 1980).

Butea monosperma may ascend upto 4000 m elevations (Beg and Khan, 1974). The plant was more commonly met with at the foothills and on the ridges of cultivated fields where they were left untouched.

Table 29 East-facing, Middle slopes (spring vegetation). Phytosociological attributes of *Pinus-Dodonaea-Oxalis* community

Name of Species	D	R.D	F	R.F	C.C	R.C.C	I.V
<i>Ajuga bracteosa</i>	1.5	3.4	0.16	8.1	3.31	3.0	15
<i>Anagallis arvensis</i>	1.49	3.2	0.05	2.5	1.35	1.2	7
<i>Apluda mutica</i> var. <i>aristata</i>	0.57	1.2	0.04	2.0	0.77	0.7	4
<i>Aristida cyanantha</i>	1.77	3.8	0.22	11.1	20.83	18.94	34
<i>Cannabis sativa</i>	4.35	9.5	0.13	6.6	4.35	3.9	20
<i>Conyza bonariensis</i>	0.95	2.1	0.12	6.1	2.31	2.1	10
<i>Cymbopogon schoenanthus</i>	0.26	0.6	0.03	1.5	2.18	2.0	4
<i>Cynodon dactylon</i>	0.92	2.0	0.06	3.0	1.23	1.1	6
<i>Erodium cicutarium</i>	0.68	1.5	0.08	4.0	1.58	1.4	7
<i>Geranium ocellatum</i>	1.4	3.0	0.11	5.6	2.18	2.0	11
<i>Gnaphalium affine</i>	2.02	4.4	0.05	2.5	2.08	1.9	9
<i>Hernaria hirsuta</i>	0.48	1.0	0.04	2.0	0.88	0.8	4
<i>Micromeria biflora</i>	4.95	10.8	0.14	7.1	3.0	2.7	21
<i>Oxalis corniculata</i>	20.66	44.9	0.3	15.2	22.15	20.1	80
<i>Polypogon schoenanthus</i>	0.09	0.2	0.01	0.5	0.81	0.7	1
<i>Rumex hastatus</i>	0.25	0.5	0.02	1.0	2.95	2.7	4
<i>Themeda anathera</i>	0.91	2.0	0.11	5.6	13.15	11.9	20
<i>Tylophora hirsuta</i>	0.09	0.2	0.01	0.5	0.42	0.4	1
<i>Viola canescence</i>	1.34	2.9	0.14	7.1	2.81	2.5	13

WOODY SPECIES

<i>Berberis lycium</i>	0.03	7.6	0.35	8.1	0.46	0.24	16
<i>Butea monosperma</i>	0.003	0.8	0.08	1.8	1.3	0.7	3
<i>Carissa opaca</i>	0.001	0.3	0.04	0.9	0.008	0.004	1
<i>Colebrookea oppositifolia</i>	0.007	1.8	0.04	0.9	0.06	0.03	3
<i>Cotoneaster nummularia</i>	0.001	0.3	0.01	0.2	0.03	0.02	1
<i>Debregeasia salicifolia</i>	0.001	0.3	0.04	0.9	0.016	0.008	1
<i>Dodonaea viscosa</i>	0.08	20.2	0.92	21.3	1.03	0.53	42

<i>Indigofera heterantha</i>	0.05	12.6	0.5	11.6	0.59	0.3	25
<i>Mallotus philippensis</i>	0.07	17.7	0.77	17.9	3.39	1.73	37
<i>Maytenus royleanus</i>	0.01	2.5	0.27	6.3	0.13	0.07	9
<i>Pinus roxburghii</i>	0.14	35.4	1.0	23.2	189.7	97.08	156
<i>Rubus ellipticus</i>	0.002	0.6	0.002	0.04	0.06	0.03	1
<i>R. nevesous</i>	0.001	0.3	0.001	0.02	0.04	0.02	1
<i>Sageretia then</i> var. <i>brandrethiana</i>	0.014	3.5	0.42	9.7	0.09	0.05	13

2. FALL VEGETATION

PINUS-DODONAEA-OXALIS COMMUNITY

The *Pinus-Dodonaea-Oxalis* community supported 27 species, 10 of which were woody (Table 30). The community dominants were the same as those of the spring vegetation and this vegetation might be a simple extension of the spring vegetation. The slopes remained dominated by *Pinus roxburghii*, *Dodonaea viscosa* and *Oxalis corniculata*. The annual herbs, however, differed. Species like *Aristida cyanantha*, *Adiantum incisum* and *Ceterarch dalhousiae* also received a good share of the total importance value of the herbaceous flora. Species like *Bidens chinensis*, *Boerhaavia coccinea*, *Ceterarch dalhousiae*, *Eragrostis pilosa*, *Erigeron alpinus*, and *Sida cordata* replaced many of the spring species. Plants of high elevations like *Ajuga bracteosa*, *Viola canescens* and *Berberis lycium* also made their entries in this community. Some very rare plants like *Mazus japonicus*, *Astragalus subumbellatus*, *Phyllanthus amblica*, *Vigna vexillata* and *Physalis minima* were also encountered here and there.

Table 30 East-facing, Middle slopes (fall vegetation). Phytosociological attributes of *Pinus-Dodonaea-Oxalis* community

Name of Species	D	R.D	F	R.F	C.C	R.C.C	I.V
<i>Adiantum incisum</i>	2.24	13.0	0.31	6.3	2.07	1.7	21
<i>Ajuga bracteosa</i>	0.36	1.9	0.17	3.5	0.86	0.6	6
<i>Apluda mutica</i> var. <i>aristata</i>	0.63	3.7	0.29	5.9	3.14	2.3	12
<i>Aristida cyanantha</i>	1.4	8.4	0.47	9.6	12.93	9.0	27
<i>Bidens chinensis</i>	0.47	2.8	0.16	3.3	0.79	0.6	7
<i>Boerhaavia coccinea</i>	0.09	0.5	0.04	0.8	0.21	0.2	2
<i>Cannabis sativa</i>	0.31	1.9	0.13	2.7	0.64	0.5	5
<i>Ceterarch dalhousiae</i>	1.89	11.2	0.31	6.3	1.71	1.1	19
<i>Eragrostis pilosa</i>	0.27	1.4	0.12	2.5	0.64	0.5	5
<i>Erigeron alpinus</i>	0.34	1.9	0.17	3.5	0.9	0.6	6
<i>Lespedeza floribunda</i>	0.29	1.9	0.14	2.9	0.71	0.5	5
<i>Oxalis corniculata</i>	3.64	21.4	0.43	8.8	2.5	1.7	32
<i>Polygonum paronychioides</i>	0.31	1.9	0.11	2.2	0.54	0.04	5
<i>Polypogon schoenanthus</i>	0.13	0.9	0.06	1.2	0.29	0.2	2
<i>Sida cordata</i>	0.03	0.17	0.01	0.2	0.07	0.06	0.4
<i>Themeda anathera</i>	0.46	2.8	0.2	4.1	5.93	4.0	11
<i>Viola canescens</i>	0.87	4.7	0.12	3.9	0.96	0.7	9

WOODY SPECIES

<i>Berberis lycium</i>	0.02	4.42	0.71	14.43	0.19	0.19	19
<i>Carissa opaca</i>	0.004	0.88	0.14	2.85	0.04	0.004	4
<i>Clematis graveolens</i>	0.004	0.88	0.01	0.20	0.04	0.004	1
<i>Dodonaea viscosa</i>	0.10	21.60	1.00	20.33	0.80	0.81	43
<i>Maytenus royleanus</i>	0.009	1.99	0.21	4.27	0.09	0.09	6
<i>Indigofera heterantha</i>	0.06	12.22	0.57	11.12	0.37	0.34	24
<i>Mallotus philippensis</i>	0.06	12.22	1.0	20.33	2.31	2.35	35
<i>Pinus roxburghii</i>	0.15	33.10	1.00	20.33	94.4	96.16	150

100

<i>Sageretia thea</i> var. <i>brandrethiana</i>	0.02	4.42	0.29	5.89	0.04	0.04	10
<i>Tylophora hirsuta</i>	0.004	1.8	0.02	0.4	0.06	0.006	2

C. UPPER SLOPES

1. SPRING VEGETATION

PINUS-BERBERIS-GERANIUM COMMUNITY

Pinus-Berberis-Geranium community stretched between 1560 and 1850 m elevation and may be considered a continuation of the corresponding community on the south facing aspect as not only the leading dominants were the same but the physical and chemical attributes of the two soils were also almost identical. The soil of this community was also sandy loam with almost the same proportion of sand, silt and clay as that of the south facing aspect. The organic matter was, however, the highest of all the communities due to the prevalence of more moisture on the site. The soil was highly acidic (Table 12).

The Community supported 42 species (Table 31) out of which 28 were common with the corresponding spring community on the south-facing aspect (Table 25).

The community was dominated by *Pinus roxburghii*, *Berberis lycium* and *Geranium ocellatum*.

P. roxburghii received the highest importance value by dint of the high values of the three community attributes. About 57% of the total importance value of the woody plants, was reposed only in *P. roxburghii* which also was responsible for 97% of the total shade cast by the woody plants. It was self perpetuating as indicated by the presence of saplings and different girth size classes (Table 17). The number of pine trees on per hectare bases was the highest on this aspect than the other two. However they were under a heavy pressure of lumbering. A number of dried trees of *P. roxburghii* were present whose pilots had been chopped off earlier.

Two very important plants, *Dodonaea viscosa* and *Mallotus philippensis*, which were very common in all other communities were surprisingly missing from these upper slopes. Both these plants climbed upto about 1480 m elevation on this aspect when *M. philippensis* made

on exit. This was followed by *D.viscosa* at 1550 m. After this elevation none were hit in any of the quadrats. On the corresponding south facing aspect which is more dry, warm and exposed a few individuals of these plants were encountered at a little higher elevation. This is clearly due to the fact that the plants have reached their upper ecological amplitude. Stewart (1972) place these limits at 1220 m and 1525 m elevations for *M.philippensis* and *D.viscosa* respectively. The thick shade cast by *P.roxburghii* and the deposition of very thick pad of its needles, which inhibits seed germination, may be yet another reasons explaining the absence of *D.viscosa* and *M.Philipensis*.

Table 31 East-facing, Upper slopes (spring vegetation). Phytosociological attributes of *Pinus-Berberis-Geranium* community

Name of Species	D	R.D	F	R.F	C.C	R.C.C	I.V
<i>Adiantum incisum</i>	3.27	8.8	0.12	7.1	6.5	4.8	21
<i>Ajuga bracteosa</i>	0.15	0.4	0.02	1.0	0.4	0.3	2
<i>Anagallis arvensis</i>	0.44	1.2	0.04	2.1	0.7	0.5	4
<i>Arenaria serpyllifolia</i>	1.1	3.0	0.05	2.96	2.0	1.5	8
<i>Artimisia scoparia</i>	0.15	0.4	0.02	1.2	0.4	0.3	2
<i>Campanula benthamii</i>	0.51	1.4	0.05	2.96	0.9	0.7	5
<i>Cannabis sativa</i>	0.29	0.8	0.03	1.78	0.5	0.4	3
<i>Cerastium dichotomum</i>	0.36	1.0	0.03	1.78	0.5	0.4	3
<i>Ceterach dalhousiae</i>	1.38	3.7	0.07	4.14	3.3	2.4	10
<i>Cheilanthes pteridioides</i>	0.07	0.2	0.01	0.59	0.2	0.1	1
<i>Conyza bonariensis</i>	0.22	0.6	0.03	1.78	0.5	0.4	3
<i>Cynodon dactylon</i>	0.07	0.5	0.01	0.59	0.2	0.1	1
<i>Dicliptera roxburghiana</i>	0.65	1.8	0.05	2.96	2.0	1.5	6
<i>Erigeron alpinus</i>	0.07	0.2	0.01	0.59	0.2	0.1	1
<i>Erodium cicutarium</i>	0.07	0.2	0.01	0.59	0.2	0.1	1
<i>Gallium aparine</i>	4.87	13.1	0.08	4.74	6.7	5.0	23
<i>Geranium ocellatum</i>	5.3	14.3	0.35	20.72	15.1	11.2	46
<i>Heteropogon contortus</i>	2.55	6.7	0.08	4.74	7.8	5.8	17
<i>Medicago orbicularis</i>	0.15	0.4	0.02	1.2	0.4	0.3	2
<i>Micromeria biflora</i>	3.56	0.6	0.14	8.29	7.1	5.3	23
<i>Oxalis corniculata</i>	0.87	2.3	0.11	6.61	2.2	1.6	10
<i>Poa infirma</i>	0.07	0.2	0.01	0.59	0.2	0.1	1
<i>Potentilla sp.</i>	0.65	1.8	0.3	1.78	1.5	1.1	5
<i>Scirpus mucronatus</i>	0.87	2.3	0.01	0.5	1.1	0.8	4
<i>Setaria pumila</i>	1.45	3.9	0.01	0.5	2.7	2.0	6
<i>Sisymbrium irio</i>	0.07	0.2	0.01	0.59	0.2	0.1	1
<i>Stipa capensis</i>	0.95	2.6	0.03	1.78	3.1	2.3	7
<i>Taraxacum officinale</i>	0.07	0.2	0.01	0.59	0.2	0.1	1

<i>Themeda anathera</i>	2.11	5.7	0.06	3.6	7.5	5.6	15
<i>Trigonella incisa</i>	0.15	0.4	0.02	1.2	0.4	0.3	2
<i>Verbascum thapsus</i>	0.07	0.2	0.01	0.59	0.2	0.1	1
<i>Vicia monantha</i>	0.87	2.3	0.05	2.96	1.8	1.3	7
<i>Viola canescense</i>	0.36	1.0	0.05	2.96	0.9	0.7	5

WOODY SPECIES:

<i>Barleria cristata</i>	0.001	0.80	0.009	0.32	0.21	0.42	2
<i>Berberis lycium</i>	0.025	20.16	0.64	26.9	0.551	1.10	48
<i>Butea monosperma</i>	0.002	1.61	0.09	3.23	0.006	0.01	5
<i>Clematis graveolens</i>	0.081	14.52	0.45	19.4	0.045	0.09	34
<i>Indigofera heterantha</i>	0.009	7.26	0.27	9.69	0.210	0.42	17
<i>Olea ferruginea</i>	0.002	1.61	0.09	3.23	0.083	0.17	5
<i>Pinus roxburghii</i>	0.057	45.97	1.00	26.90	48.59	97.44	170
<i>Plectranthus rugosus</i>	0.002	1.61	0.01	0.36	0.90	1.8	4
<i>Rubus ellipticus</i>	0.01	8.06	0.27	12.10	0.38	0.76	21

2. FALL VEGETATION

PINUS-BERBERIS-OXALIS COMMUNITY

The *Pinus-Berberis-Oxalis* community was dominated by *Pinus roxburghii* from the arborescent layer, *Berberis lycium* from the shrub substratum while *Oxalis corniculata* dominated the herbaceous flora. There were a total of 24 species seven of which were woody (Table 32).

The community as a whole was closely similar to that of the spring community on the corresponding elevation of the south facing aspect and may, in fact be, considered as a continuation of the same as 53 species were common to both these communities and their woody dominants were also the same (Table 26). In the herbaceous stratum, however, *Oxalis corniculata* replaced *Geranium ocellatum*.

O. corniculata became dominant due to the presence of suitable edaphic and climatic conditions which favoured the occurrence of the plant all over the area. This is manifested by the highest values of density and frequency. The canopy cover value, however, was small as it is a small sized herb.

Micromeria biflora seemed to be trying to catch up with *O. corniculata* by dint of its larger canopy cover but failed to do so due to having low values of density and frequency. Other herbaceous species included *Colebrookea oppositifolia*, *Aristida cyanantha*, *Adiantum incisum*, *Ceterarch dalhousiae* and *Conyza bonariensis*. Among the rare plants were included *Cannabis sativa*, *Plectranthus rugosus*, *Polygonum paronychioides*, *Lespedeza floribunda* and *Setaria pumila*.

Table 32 East-facing, Upper slopes (fall vegetation). Phytosociological attributes of *Pinus-Berberis-Oxalis* community

Name of Species	D	R.D	F	R.F	C.C	R.C.C	I.V
<i>Adiantum incisum</i>	1.43	9.43	0.21	5.93	1.06	0.96	16
<i>Ajuga bracteosa</i>	0.13	0.86	0.06	1.69	0.13	0.12	3
<i>Apluda mutica</i> var. <i>aristata</i>	0.13	0.86	0.06	1.69	1.88	1.69	4
<i>Aristida cyanantha</i>	0.55	3.6	0.26	7.34	9.0	8.11	19
<i>Bidens chinensis</i>	0.38	2.5	0.19	5.37	0.94	0.85	9
<i>Cannabis sativa</i>	0.13	0.86	0.06	1.69	0.31	0.28	3
<i>Ceterarch dalhousiae</i>	1.53	10.1	0.19	5.37	0.93	0.84	16
<i>Conyza bonariensis</i>	0.5	3.3	0.24	6.78	1.19	1.07	11
<i>Lespedeza floribunda</i>	0.18	1.19	0.09	2.54	0.44	0.4	4
<i>Micromeria biflora</i>	2.93	19.3	0.29	8.19	2.75	2.48	30
<i>Oxalis corniculata</i>	4.1	27.0	0.41	11.58	2.06	1.86	40
<i>Polygonum paronychioides</i>	0.08	0.53	0.04	1.13	0.08	0.07	2
<i>Setaria pumila</i>	0.08	0.53	0.03	0.85	1.0	0.90	2
<i>Themeda anathera</i>	0.25	1.65	0.05	1.41	1.19	1.07	4
<i>Viola canescens</i>	0.3	1.98	0.14	3.95	0.69	0.62	7

WOODY SPECIES

<i>Berberis lycium</i>	0.55	18.9	0.88	23.4	4.84	0.2	43
<i>Clematis graveolens</i>	0.08	0.53	0.04	1.13	0.19	0.17	2
<i>Colebrookea oppositifolia</i>	0.08	0.53	0.02	0.56	0.20	0.18	1
<i>Dodonaea viscosa</i>	0.53	18.2	0.75	19.9	6.93	0.3	38
<i>Indigofera heterantha</i>	0.38	13.1	0.63	16.8	7.81	0.3	30
<i>Mallotus philippensis</i>	0.3	10.3	0.5	13.3	16.02	0.7	24
<i>Pinus roxburghii</i>	1.15	39.5	1.0	26.6	2198.4	98.4	165
<i>Sageretia thea</i> var. <i>brandrethiana</i>	0.05	0.33	0.03	0.85	2.5	2.25	3
<i>Tylophora hirsuta</i>	0.04	0.26	0.01	0.28	1.3	1.10	2

VEGETATION OF THE MEADOWS

Meadows are small flat lands developed due to topographic relief and have better developed soils with high water retaining capacity. They are usually more exposed and mostly support grasses and forbes. They act as grazing pastures or resting grounds for the animals. Their characters are, therefore, a product of the environmental factors present and the degree of their isolation while their vegetation, beside other factors, is controlled and determined by the type and magnitude of grazing. Over grazing and trampling reduces species richness (Wheeler, 1980).

A few such stands were also encountered in Ambela at different elevations both on the south- and east-facing aspects whose vegetation was found different from the surroundings. The ground flora was mostly grasses or small herbs. These were surrounded by a mixture of bushy plants which, in turn, blended with the surrounding arborescent plants. Three such meadows were sampled both in the spring and fall and are discussed here separately.

MEADOW I

1. SPRING VEGETATION

OXALIS-GNAPHALIUM COMMUNITY

The meadow supporting *Oxalis* - *Gnaphalium* community was situated at about 1190 m elevation. The slope was very gentle and the topography was almost flat with soil depth between 15 cm and 30 cm. The electrical conductivity, sodium contents, sodium absorption ratio and organic matter contents were the highest of all the communities. Saturation percentage was high and the soil was highly acidic and sandy loam. (Table 33). Being the abode of grazing ungulates dried as well as fresh excreta was found scattered here and there. The temperature was 19°C.

The community supported 15 different species most of which were grasses and other herbs. No woody species was present. However, *Pinus roxburghii*, *Dodonaea viscosa* and *Mallotus philippensis* were seen surrounding the meadow.

The dominant species were *Oxalis corniculata* and *Gnaphalium affine* and their dominance was the result of the highest contribution of all the three community attributes. In fact about 52% of the total importance value was reposed in these two species while the rest was shared unequally by the remaining 13 species (Table 34).

O. corniculata took the lead over *G. affine* by having slightly higher relative values of the three parameters especially the canopy coverage. It is a shade loving small herb with shallow roots and inhabits moist shady soils and water courses (Salim and Shahid, 1973; Chaghtai *et al.*, 1985a). It is a slender much branched, decumbent annual which is a garden escape and has naturalized in several places as a weed (Butcher 1961; and Haines, 1921). Sandy loam soils, such as this one, seem to be highly favourable for its luxuriant growth.

Table 33 Soil characteristics of Meadows

	Meadow 1	Meadow 2	Meadow 3
Soil parameters	1190 m	1410 m	1580 m
Saturation percentage	27.00	23.00	28.00
pH	6.10	6.40	6.80
Electrical conductivity	0.21	0.95	0.13
Na ⁺⁺ meq/l	0.46	0.35	0.24
Ca ⁺⁺ meq/l	1.50	1.50	1.60
Ca ⁺⁺ + Mg ⁺⁺ meq/l	2.80	2.25	3.90
Sodium Absorption Ratio	0.49	0.33	0.48
Organic matter	0.70	0.46	0.39
Sand %	71.50	70.08	72.59
Silt %	20.51	21.76	20.75
Clay	8.01	8.16	6.66
	Sandy Loam	Sandy Loam	Sandy Loam

Gnaphalium affine, the co-dominant member, is a spring annual reproducing by under-ground runner as well as seeds. It is usually among the first few pioneers colonizing an area (Simon, 1984). It favours loamy sand soils (Chaghtai *et al.*, 1987) which largely explains its abundance here.

The habitat was extremely suitable for *O. corniculata* but the dominance of *G. affine* reflects upon its vast ecological amplitude than its liking for moist places. The dominant species had produced such a well knit combination that they did not allow the supporting species to sufficiently show their trait. It was due to this reason that the supporting species were so much subdued.

Table 34 Spring vegetation of Meadow I (elevation 1190 m). Phytosociological attributes of *Oxalis-Gnaphalium* community

Name of Species	D	R.D	F	R.F	C.C	R.C.C	I.V
<i>Ajuga bracteosa</i>	2.4	1.2	0.25	4.6	5.5	2.4	8
<i>Anagallis arvensis</i>	8.0	4.0	0.31	5.7	6.3	2.84	13
<i>Apluda mutica</i> var <i>aristata</i>	2.3	1.1	0.25	4.6	5.0	2.2	8
<i>Arenaria serpyllifolia</i>	5.8	2.9	0.31	5.7	6.0	2.7	11
<i>Cannabis sativa</i>	12.3	6.1	0.38	6.9	10.0	4.4	17
<i>Erodium cicutarium</i>	9.1	4.5	0.38	6.9	7.6	3.4	15
<i>Gagea elegans</i>	2.7	1.3	0.25	4.6	5.0	2.2	8
<i>Gnaphalium affine</i>	60.7	30.0	0.75	13.7	57.0	25.3	69
<i>Hernaria hirsuta</i>	9.2	4.5	0.44	8.0	8.8	3.9	16
<i>Medicago orbicularis</i>	7.5	3.7	0.39	7.1	7.8	3.5	14
<i>Micromeria biflora</i>	4.5	2.2	0.25	4.6	5.0	2.2	9
<i>Oxalis corniculata</i>	71.5	35.3	0.84	15.4	79.0	35.0	86
<i>Poa infirma</i>	3.1	1.5	0.31	5.7	6.3	2.8	10
<i>Taraxacum officinale</i>	1.3	6.6	0.15	2.7	3.0	1.3	5
<i>Themeda anathera</i>	1.9	0.9	0.21	3.8	13.1	5.8	11

2. FALL VEGETATION

CANNABIS-CYNODON COMMUNITY

The same meadow was re-sampled in September to November (fall season) and was now found dominated by *Cannabis-Cynodon* community. The temperature varied between 38°C and 40°C. There were a total of 14 different species among which *Cannabis sativa* and *Cynodon dactylon* attained highest importance values. In fact 77% of the total value was reposed in these two species only. Their dominance was the result of very high values of all the community attributes (Table 35).

Cannabis sativa is a very common erect shrub of organically rich moist soils and stream banks and propagates by nuts well protected by the inner segments of the persistent perianth (Salim and Shahid, 1973). The species ascends upto 2400 m in the Himalayan or sub-Himalayan tract and colonizes fresh mineral soils especially on slopes at high elevation or meadows where it becomes very common. It flowers from May-October (Parker, 1956). The plant dries up in late autumn. It is cathartic and unpalatable and the mature plants are avoided especially in the presence of other palatable plants. This explains its dominance here.

Cynodon dactylon is a very common grass of grazing grounds, waste places and road sides especially when they are not very dry (Parker, 1956). The grass favours calcareous sandy loam soils and openness of stands (Burton, 1944; Anonymous, 1958; and Ramakrishanan and Singh, 1966) and may be one of the reasons for its abundance here. Trampling and trafficking effects of the grazing animals also favour the growth of *C. dactylon* (Siniscalco and Montacchini, 1983/84).

Selective grazing had removed most of the palatable species while forbes, like *Dicliptera roxburghiana* and *Oenothera rosea*, were left to grow. Other plants of less importance

were *Oxalis corniculata*, *Themeda anathera*, *Euphorbia pilulifera*, *Conyza bonariensis*, *Ceterarch dalhousiae*, *Barleria cristata* and *Chenopodium album*. Woody plants surrounding the meadow were *Berberis lycium*, *Justicia adhatoda* and *Sageretia thea* var *brandrethiana* etc.

Table 35 Fall vegetation of Meadow I (elevation 1190 m). Phytosociological attributes of *Cannabis-Cynodon* community

Name of Species	D	R.D	F	R.F	C.C	R.C.C	I.V
<i>Barleria cristata</i>	0.5	0.4	0.06	1.9	7.5	1.46	4
<i>Berberis lycium</i>	0.2	0.2	0.03	0.9	3.0	0.58	2
<i>Cannabis sativa</i>	48.0	39.9	0.9	28.2	247.75	48.3	116
<i>Ceterarch dalhousiae</i>	0.3	0.2	0.04	1.3	0.75	0.15	2
<i>Chenopodium album</i>	0.7	0.6	0.09	2.8	1.75	0.3	4
<i>Conyza bonariensis</i>	1.4	1.2	0.08	2.5	3.75	0.73	4
<i>Corchorus trilocularis</i>	0.2	0.2	0.01	0.3	0.5	0.1	1
<i>Cynodon dactylon</i>	56.9	47.3	0.83	26.0	212.0	41.3	115
<i>Dicliptera roxburghiana</i>	6.4	5.3	0.48	15.0	21.75	4.2	25
<i>Euphorbia pilulifera</i>	1.4	1.2	0.08	2.5	3.75	0.73	4
<i>Oenothera rosea</i>	1.9	1.6	0.23	7.2	4.5	0.9	10
<i>Oxalis corniculata</i>	0.7	0.6	0.05	1.57	1.0	0.22	3
<i>Portulaca oleracea</i>	1.5	1.2	0.19	5.96	3.75	0.7	8
<i>Themeda anathera</i>	0.7	0.6	0.09	2.8	3.0	0.58	4

MEADOW II

1. SPRING VEGETATION

SALVIA-OXALIS-GNAPHALIUM COMMUNITY

Salvia-Oxalis-Gnaphalium community occurred at 1410 m elevation. The soil was sandy loam with comparatively high silt and clay contents and low sand. The electrical conductivity was the highest of all the meadows but calcium and magnesium contents and the sodium absorption ratio were the lowest (Table 33). The depth of the soil varied from 14-36 cm. The temperature was 18°C.

The community supported 16 species out of which *Salvia moorcroftiana*, *Oxalis corniculata* and *Gnaphalium affine* were dominant (Table 36). *S.moorcroftiana* took the lead by having a large canopy otherwise its density and frequency values were less than those of *O.corniculata*. *S.moorcroftiana* is a tall herb, which perennates by underground thick and succulent stem and is abundant in Swat from 600-2400 m (Stewart, 1972). Once rooted it colonizes the area rapidly. It appears to favour soft moist but open soils and cool climate.

O.corniculata, a plant of moist places, became dominant due to high values of density and frequency but being a small sized herb could not compete with *S.moorcroftiana*. Even then its contribution towards coverage was substantial due to the presence of very large number of individuals. Thus the overall importance values of the two were equal.

G.affine and *O.corniculata* were present in this community and also in the same proportion as that of *Oxalis-Gnaphalium* community at 1190 m elevation (Table-34). The number of common species shared by the two communities was also quite high suggesting a close similarity between the two meadows. It can, thus, safely be stated that *S.moorcroftiana* finding the factors conducive for its growth, entered this community and pushed off *O.corniculata* and *G.affine* to the second and third positions respectively.

Among the other herbs *Arenaria serpyllifolia* received slightly greater share of importance value due to a high value of frequency. The rest of the importance value was shared almost equally by the remaining species.

The meadow was surrounded by some woody plants which included *Dodonaea viscosa*, *Sageretia thea* var *brandrethiana* and *Indigofera heterantha*.

Table 36 Spring vegetation of Meadow II (elevation 1410 m). Phytosociological attributes of *Salvia-Oxalis-Gnaphalium* community

Name of Species	D	R.D	F	R.F	C.C	R.C.C	I.V
<i>Ajuga bracteosa</i>	2.0	1	0.25	4	5.0	2	7
<i>Anagallis arvensis</i>	2.0	1	0.25	4	5.0	2	7
<i>Apluda mutica</i>	2.3	1	0.29	5	5.8	2	8
<i>Arenaria serpyllifolia</i>	14.5	7	0.46	8	14.2	6	21
<i>Aristida cyanantha</i>	2.1	1	2.5	4	6.0	2	7
<i>Cannabis sativa</i>	5.1	3	0.33	6	6.6	3	12
<i>Conyza bonariensis</i>	1.9	1	0.24	4	4.8	2	7
<i>Erodium cicutarium</i>	3.8	2	0.32	5	6.4	3	10
<i>Gnaphalium affine</i>	46.4	23	0.63	11	35.2	14	48
<i>Medicago orbicularis</i>	2.4	1	0.24	4	4.8	2	7
<i>Oxalis corniculata</i>	57.0	28	0.83	14	56.7	23	65
<i>Poa infirma</i>	1.4	1	0.18	3	3.6	1	5
<i>Potentilla</i> sp.	2.1	1	0.27	5	5.4	2	8
<i>Salvia moorcroftiana</i>	48.8	24	0.79	13	69.6	29	66
<i>Trifolium repens</i>	2.4	1	0.28	5	5.6	2	8
<i>Veronica arvensis</i>	4.4	2	0.33	6	6.6	3	11

2. FALL VEGETATION

POA-SETARIA-CYPERUS-CYNODON COMMUNITY

The same meadow which supported *Saliva-Oxalis-Gnaphalium* community in spring supported *Poa-Setaria-Cyperus-Cynodon* community in the fall. The temperature ranged between 31°-32°C. There were only 11 species, 4 of which were grasses and one was a sedge. Three of the grasses namely *Poa infirma*, *Setaria pumila* and *Cynodon dactylon* and one sedge, namely *Cyperus rotundus*, gained the dominance. About 93% of the total importance value was reposed in these four species while the rest of the species shared equally the remaining 7% importance value (Table 37). The meadow was heavily grazed as indicated by the presence of dried and fresh cattle dung.

Poa infirma received the highest importance value. All the three community attributes, particularly the canopy coverage, contributed highly to its success. *P. infirma* has also been reported by Cope (1982) from Swat upto 3000. It is a plant of trampled and disturbed areas (Siniscalco and Montacchini, 1983/84). Its seeds flourish well in the dung particularly that deposited in autumn (Welch, 1985) which may account for its dominance here. *P. infirma* is a plant of northern hemisphere and is an excellent pasture grass (Bor, 1960). It spreads very well by lateral tillers (Fowler, 1982).

Setaria pumila, the co-dominant member, is avoided by cattle once the spikes appear (Cope, 1982) and might explain its abundance here as it was in this condition at the time of sampling.

Cyperus niveus, another co-dominant species of this community received only half the importance value of *P. infirma*. It is a plant of exposed wet places rarely found in shade upto 1200 m (Salim and Shahid, 1973).

Cynodon dactylon, the fourth co-dominant member of the community, is a sward forming stolon bearing perennial grass which grows very well in tropical and warm temperate regions. Being a first class fodder it suffers overgrazing badly (Cope, 1982) and hence received relatively less importance value.

The meadow was surrounded by big boulders. Woody plants in the surrounding were *Berberis lycium* and a few *Dodonaea viscosa* individuals.

Table 37 Fall vegetation of Meadow II (elevation 1410 m). Phytosociological attributes of *Poa-Setaria-Cyperus-Cynodon* community

Name of Species	D	R.D	F	R.F	C.C	R.C.C	I.V
<i>Ajuga bracteosa</i>	0.8	0.59	0.1	3.02	2.00	0.76	4
<i>Cannabis sativa</i>	0.2	0.15	0.03	0.91	0.5	0.19	1
<i>Cynodon dactylon</i>	18.2	13.2	0.63	19.0	39.25	15.00	47
<i>Cyperus niveus</i>	22.8	16.7	0.59	17.8	42.75	16.35	51
<i>Dicliptera roxburghiana</i>	0.8	0.6	0.1	3.02	2.00	0.76	2
<i>Geranium ocellatum</i>	0.6	0.4	0.08	2.42	1.5	0.57	3
<i>Micromeria biflora</i>	0.3	0.2	0.04	1.21	2.00	0.76	2
<i>Oxalis corniculata</i>	1.0	0.73	0.09	2.72	3.0	1.15	2
<i>Poa infirma</i>	53.6	39.3	0.83	25.1	93.75	35.9	100
<i>Rumex hastatus</i>	0.7	0.5	0.09	2.72	1.7	0.65	4
<i>Setaria pumila</i>	37.5	27.5	0.73	22.1	73.05	27.9	78

MEADOW III

1. SPRING VEGETATION

FILAGO-OENOTHERA COMMUNITY

The meadow supporting *Filago-Oenothera* community was situated at 1580 m elevation. The soil was sandy loam with the highest percentage of sand in all the three communities. Similarly the saturation percentage and calcium and magnesium contents were the highest whereas the electrical conductivity, sodium and organic matter contents were the lowest and the soil was very slightly acidic (Table 33). The depth of the soil varied between 18-44 cm and the temperature between 18-20°C.

There were 16 different species in this community which were dominated by *Filago pyramidata* and *Oenothera rosea*. (Table 38).

Filago pyramidata is a small sized wild herb. It has also been reported by Stewart (1967) from the area. It was very common in the area probably due to favourable soil factors and greater exposure.

Oenothera rosea had lower density and coverage values than *F. pyramidata* but its frequency was high. It is an American weed naturalized in many places in this sub-continent (Stewart, 1972). The meadow was bordered on all sides by *Indigofera heterantha* and *Berberis lycium* bushes which are plants of high altitude.

Table 38 Spring vegetation of Meadow III (elevation 1580 m). Phytosociological attributes of *Filago-oenothera* community

Name of Species	D	R.D	F	R.F	C.C	R.C.C	I.V
<i>Anagallis arvensis</i>	4.6	2.31	0.125	0.72	3.75	0.96	6
<i>Arenaria serpyllifolia</i>	6.4	3.22	0.375	8.15	14.75	3.77	15
<i>Cynodon dactylon</i>	23.2	11.66	0.363	7.89	67.5	17.23	37
<i>Erodium cicutarium</i>	13.9	6.99	0.5	10.87	27.5	7.02	25
<i>Filago pyramidata</i>	75.1	37.76	0.638	13.87	118.75	30.31	82
<i>Fragaria nubicola</i>	0.9	0.45	0.087	1.89	3.25	0.83	3
<i>Gagea elegans</i>	3.4	1.71	0.29	6.26	8.25	2.11	10
<i>Oenothera rosea</i>	37.8	19.00	0.9	19.57	79.25	20.23	59
<i>Medicago orbicularis</i>	1.4	0.70	0.113	2.46	2.25	0.57	4
<i>Micromeria biflora</i>	0.9	0.45	0.113	2.46	2.25	0.57	4
<i>Oxalis corniculata</i>	5.5	2.77	0.225	4.89	17.75	4.53	12
<i>Plantago lanceolata</i>	8.0	4.02	0.188	4.09	12.5	3.19	11
<i>Themeda anathera</i>	1.2	0.60	0.063	1.37	6.25	1.60	4
<i>Valerienella szowitziana</i>	2.6	1.31	0.2	4.35	4.0	1.02	7
<i>Veronica arvensis</i>	13.5	6.79	0.38	8.15	20.5	5.17	20
<i>Viola canescens</i>	0.5	0.25	0.05	1.09	3.5	0.89	2

2. FALL VEGETATION

CYNODON-CYPERUS COMMUNITY

The meadow, supporting *Filago-Oenothera* community in spring, was now dominated by *Cynodon-Cyperus* community. There were 12 different species present out of which five namely *Cymbopogon schoenanthus*, *Cynodon dactylon*, *Dichanthium annulatum*, *Poa infirma* and *Setaria pumila* were grasses of high fodder value while the sixth one *Cyperus niveus*, was a sedge of equally good palatability; the rest were forbes (Table 39). *Cynodon dactylon* and *Cyperus niveus* became the dominant plants. About 56% of the total importance value was shared by these two plants only. This high importance value was contributed by all the three community parameters.

C.dactylon is a plant of tropical and warm temperate regions throughout the world but suffers heavily from over grazing (Cope, 1982) while Siniscalco and Montacchini (1983/84) consider the grass to withstand trampling and Furness and Breen (1985) have reported a stimulating effect of defoliation on its growth. The plant becomes abundant after the monsoon rains both in plains and hills and as previously mentioned, is fond of openness of stand and calcareous sandy soil. These factors well explain its dominance at this grazing pasture.

Cyperus niveus, the co-dominant member, is a plant of wet exposed places upto 1280 m and is rare in shades (Salim and Shahid, 1973). The soil of this meadow was moist and the atmosphere cool due to high altitude and *C.niveus* found it suitable for its growth and flourishing.

Other plants of some importance in the community were *Cannabis sativa* and *Oxalis corniculata*. The meadow was surrounded by big lofty trees of *P.roxburghii*. Due to mesic conditions *Mallotus philippensis* had also grown to tree stature. Other Woody plants in the vicinity were *Olea ferruginea*, *Ficus palmata* and *Pistacia integerrima*.

Table 39 Fall vegetation of Meadow III (elevation 1580 m). Phytosociological attributes of *Cynodon-Cyperus* community

Name of Species	D	R.D	F	R.F	C.C	R.C.C	I.V
<i>Cannabis sativa</i>	7.2	9.7	0.72	15.3	59.5	14.3	39
<i>Conyza bonariensis</i>	1.7	2.3	0.21	4.4	4.25	1.0	8
<i>Cymbopogon schoenanthus</i>	2.6	3.5	0.32	6.8	7.75	1.9	12
<i>Cyperus niveus</i>	16.9	22.7	0.88	18.6	115.25	27.8	69
<i>Cynodon dactylon</i>	27.3	36.6	0.9	19.1	175.25	42.4	98
<i>Dichanthium annulatum</i>	1.2	1.6	0.15	3.2	3.00	0.7	6
<i>Euphorbia pilulifera</i>	1.3	1.7	0.16	3.4	3.25	0.8	6
<i>Micromeria biflora</i>	3.5	4.7	0.21	4.4	4.25	1.0	10
<i>Oenothera rosea</i>	2.0	2.7	0.25	5.3	4.75	1.1	9
<i>Oxalis corniculata</i>	6.3	8.4	0.48	10.2	23.0	5.5	24
<i>Poa infirma</i>	2.1	2.8	0.21	4.4	10.25	2.5	10
<i>Setaria pumila</i>	2.5	3.4	0.23	4.9	4.55	1.1	9

COEFFICIENT OF SIMILARITY OF THE COMMUNITIES

The mountains are discernable into distinct slopes covered by separate plant communities (Table 2). The north facing aspect is not very high and is divisible into two slopes only; the lower and the middle. The upper zone is missing due to low elevation. The south- and north-facing aspects are divisible into lower, middle and upper slopes on the bases of different communities they support. The south-facing aspect, however, also bears an additional lower most belt on the lesser steep portion of the foot hills. This was dominated, beside other common woody plants, by *Justicia adhatoda* in the spring and *Helicteres isora* in the fall. Both these are perennial plants of low elevations quickly colonizing gentle slopes waste places and ravines (Troup, 1921; and Anonymous, 1980).

A. LOWER SLOPES

They stretch upto about 850 m elevation on the north-facing, 1300 mm on the south facing and 1150 m on the east-facing aspects. The common dominants were *Mallotus philippensis* from the arborescent layer and *Dodonaea viscosa* from the shrub layer. The herbaceous members, however, varied not only according to the seasons but also to the microclimates determined and controlled by aspects, altitude and other environmental factors. In spring *Themeda anathera* dominated these slopes on all the three aspects while in fall *Poa pratensis* dominated these lower slopes on the north facing aspect, *Oxalis corniculata* on the south facing and *Aristida cyanantha* on the east facing aspects (Table 2).

The community on the lower slopes of the north facing aspects showed less similarity with its corresponding communities of the other two aspects (Table 40 A). The habitat here was suitable for the prevalence of the dominant species similar to those of the corresponding communities but because of the difference in the micro-relief features, the under storey vegetation in these communities was significantly different as a result of which the index of similarity dropped down.

The communities on the lowermost and lower slopes of the south-facing aspect bear close similarity to that occupying the lower slopes of the east-facing aspect (Table 40 A) with a high percentage value of the common species.

B. MIDDLE SLOPES

These ranged between 850 and 1350 m elevation on the north-facing aspect, 1300 and 1550 m on the south-facing and 1150 and 1550 m on the east-facing aspects. *Pinus roxburghii* had appeared on these middle slopes and had acquired dominant position among the arborescent members largely because of its high canopy coverage values. As a result it had subdued *Mallotus philippensis*. The latter had also started receding into oblivion on these slopes due to reaching its upper ecological amplitude (Troup, 1921; and Parker, 1956). *Dodonaea viscosa*, however, continued to dominate the slopes as representative of the shrub layer from 1400 m elevation to even 1900 m on the hot, dry and more exposed south facing slopes. The herbaceous dominants again varied. *Micromeria biflora*, *Rumex hastatus* and *Oxalis corniculata* were dominant members in the spring while *Setaria pumila*, *M.biflora* and *O.corniculata* were dominants in the fall season.

The communities of these slopes on all the aspects bear high similarity with each other (Table 40 B). An exception is that of the communities occupying the middle slopes of the

north- and south-facing aspects where the value of similarity has dropped low. This may be due to the biotically disturbed status of the community occupying the south-facing aspect which is also indicated by the occurrence of the lowest number of species (Table 23).

C. UPPER SLOPES

These were confined to the south- and east-facing mountains only. The maximum elevation of this zone was 1905 m on both the aspects and the dominant members of the corresponding communities were completely identical both in the spring and the fall seasons.

The communities occupying these slopes on both the south- and east-facing aspect bear the highest value of similarity and highest percent value of common species (Table 40 C).

Thus the communities occupying the same slopes on the three different aspects show close similarities with each other; a fact which hints at the presence of three continuous wavy belts of vegetation on these mountains. The range and altitudes of these belts, however, depend on the aspect and the micro-climate prevailing over there. On the hot and more exposed south-facing aspect they extend a little higher than on the cooler and less exposed north- and east-facing aspects.

Table 40 Matrix of Coefficient of Similarity between communities of different aspects but same slopes (spring vegetation)
(Percent values of common species are given in parenthesis)

A: LOWER SLOPES

Communities	<i>Mallotus-Dodonaea-Themeda</i> (N.F.)	<i>Dodonaea-Justicia-Themeda</i> (S.F.)	<i>Mallotus-Dodonaea-Themeda</i> (S.F.)	<i>Mallotus-Dodonaea-Themeda</i> (E.F.)
<i>Mallotus-Dodonaea-Themeda</i> (N.F.)	-	47 (23)	41 (21)	39 (20)
<i>Dodonaea-Justicia-Themeda</i> (S.F.)	-	-	53 (27)	54 (27)
<i>Mallotus-Dodonaea-Themeda</i> (S.F.)	-	-	-	66 (35)
<i>Mallotus-Dodonaea-Themeda</i> (E.F.)	-	-	-	-

B: MIDDLE SLOPES

	<i>Pinus-Dodonaea-Micromeria</i> (N.F.)	<i>Pinus-Dodonaea-Rumex</i> (S.F.)	<i>Pinus-Dodonaea-Oxalis</i> (E.F.)
<i>Pinus-Dodonaea-Micromeria</i> (N.F.)	-	44 (24)	56 (29)
<i>Pinus-Dodonaea-Rumex</i> (S.F.)	-	-	51 (27)
<i>Pinus-Dodonaea-Oxalis</i> (E.F.)	-	-	-

C: UPPER SLOPES

	<i>Pinus-Berberis-Geranium</i> (S.F.)	<i>Pinus-Berberis-Geranium</i> (E.F.)
<i>Pinus-Berberis-Geranium</i> (S.F.)	-	68 (35)
<i>Pinus-Berberis-Geranium</i> (E.F.)	-	-

N.F = North Facing: S.F = South Facing and E.F = East Facing

DISTRIBUTION OF THE MAJOR WOODY DOMINANTS ON DIFFERENT ASPECTS:

1. *DODONAEA VISCOSA*

This was the most common and by far the most abundant species covering all the three aspects from the base to about 1700 m elevation and constituted most of the understorey vegetation of the pine zone. It had always shown up as one of the dominant shrub in 13 different communities occupying the first dominant position in one while in the rest of the 12 communities it occupied the second position after the arborescent members (Table 41).

On the north-facing aspect the plant covered the area starting from the base of the ravine to 1175 m elevation. The density of the plant varied from 0.09 to 0.42, frequency from 0.01 to 0.35 and the canopy cover from 0.18 to 3.13 (Table 42). These values were quite high for plants near the ravine at 550 m. The plants were generally young at 575 m as indicated by a high density and low canopy cover values (Fig.3). They started increasing in size and reached the peak between 725 m and 775 m elevation. In this region though the frequency became the lowest, yet the high density and the highest canopy coverage values hint at the clumping of many large and mature plants. The gradient was very steep here and large inaccessible boulders were present. As such the plants were well protected from biotic interferences. At 825 m elevation the area was highly disturbed due to the passage of the metalled road connecting Rustam Town with Pir Baba Valley and the heavy traffic passing by it. At about 900 m elevation the pine zone started and *D. viscosa* went on decreasing in size, density as well as frequency most probably due to the shade effect.

On the south-facing aspect *D. viscosa* occurred between 550 m and 1675 elevation (Table 43). It started increasing in size till 925 m elevation. Beyond this and upto 1200 m

Table 41 Dominant plants of the different strata and their relative positions in the different communities on the basis of their importance values.

Spring flora										Fall flora																				
Aspect ▶	N.F.					S.F.					E.F.					N.F.					S.F.					E.F.				
	MDT	PDMi	DJT	MDT	PDR	PBG	MDT	PDO	PBG	MDP	PDS	MHO	MDO	PDM	PBO	MDA	PDO	PBO												
Communities ▶																														
Name of species ▼																														
<i>Aristida cyanantha</i>						41"			48"						70"			43"												
<i>Berberis lycium</i>																														
<i>Dodonaea viscosa</i>	190"	66"	9"	64"	125"		55"	42"		60"	44"		170"	81"		92"	64"													
<i>Geranium ocellatum</i>						58"			44"																					
<i>Helecteres isora</i>											119"																			
<i>Justicia adhatoda</i>			70"																											
<i>Mallotus philippensis</i>	73"			28"			64"			71"		62"	137"		109"															
<i>Micromeria biflora</i>		38"												62"																
<i>Oxalis corniculata</i>									80"			74"	33"		56"		32"	40"												
<i>Poa parietensis</i>										91"																				
<i>Pinus roxburghii</i>		139"		72"	189"		156"	170"			138"			88"	144"		129"	165"												
<i>Rumex hastatus</i>					36"																									
<i>Setaria pumila</i>											55"																			
<i>Themeda anathera</i>	71"		66"	49"			38"																							

LEGENDS:

- N.F.

: North Facing

M.D.T

: Mallotus-Dodonaea-Themeda

P.D.Mi.

: Pinus-Dodonaea-Micromeria

M.D.Po

: Mallotus-Dodonaea-Poa

P.D.S.

: Pinus-Dodonaea-Setaria

M.H.O.

: Mallotus-Helecteres-Oxalis
- S.F.

: South Facing
- D.J.T

: Dodonaea-Justicia-Themeda
- P.D.R.

: Pinus-Dodonaea-Rumex
- P.B.G.

: Pinus-Berberis-Geranium
- P.D.O.

: Pinus-Dodonaea-Oxalis
- M.D.O.

: Mallotus-Dodonaea-Oxalis

E.F.

: East facing

M.D.A.

: Mallotus-Dodonaea-Aristida

P.B.O.

: Pinus-Berberis-Oxalis

*

: First dominant

**

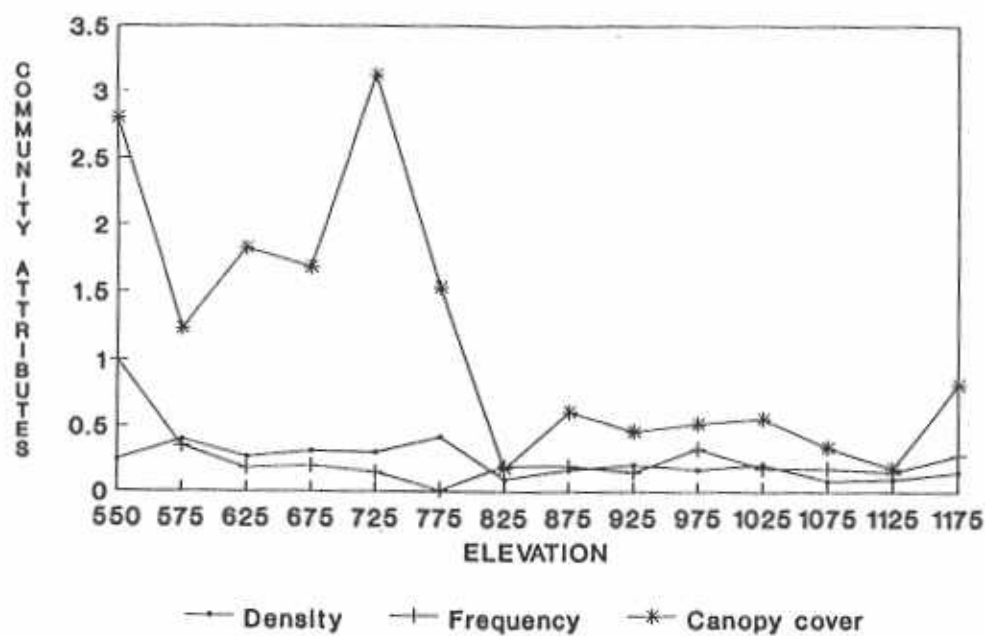
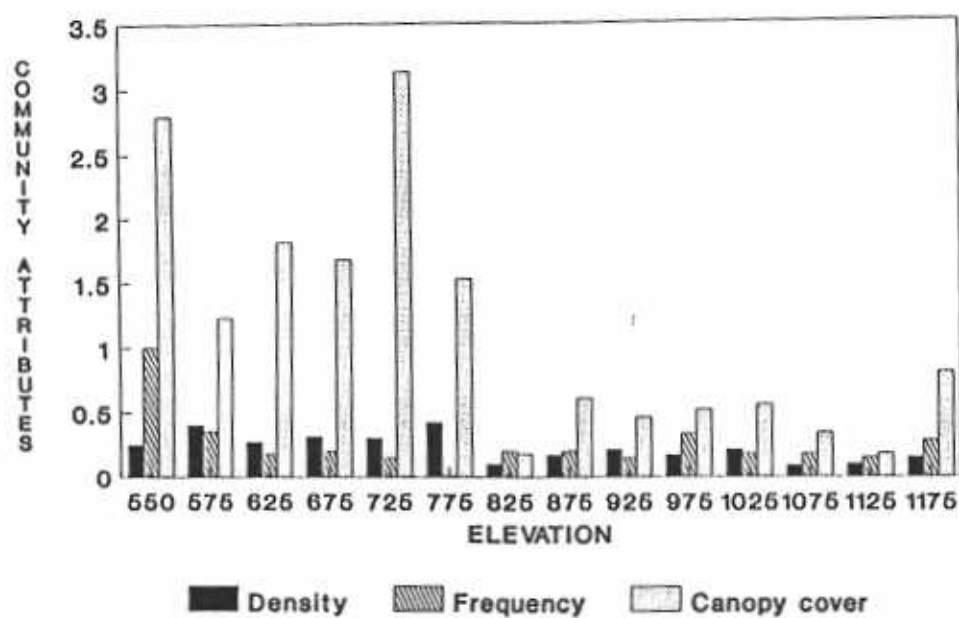
: Second dominant

: Third dominant

Table 42 Community attributes vs elevation of *Dodoneae viscosa* on North facing slopes

Elevation	Density	Frequency	Canopy Cover
550	0.25	1.00	2.80
575	0.40	0.35	1.23
625	0.27	0.18	1.82
675	0.31	0.20	1.68
725	0.30	0.15	3.13
775	0.42	0.01	1.53
825	0.10	0.20	0.18
875	0.17	0.20	0.61
925	0.21	0.15	0.46
975	0.17	0.33	0.52
1025	0.12	0.18	0.56
1075	0.09	0.18	0.34
1125	0.10	0.15	0.18
1175	0.15	0.28	2.81

FIG.3 Community attributes vs elevation
Dodonaea viscosa (North Facing)

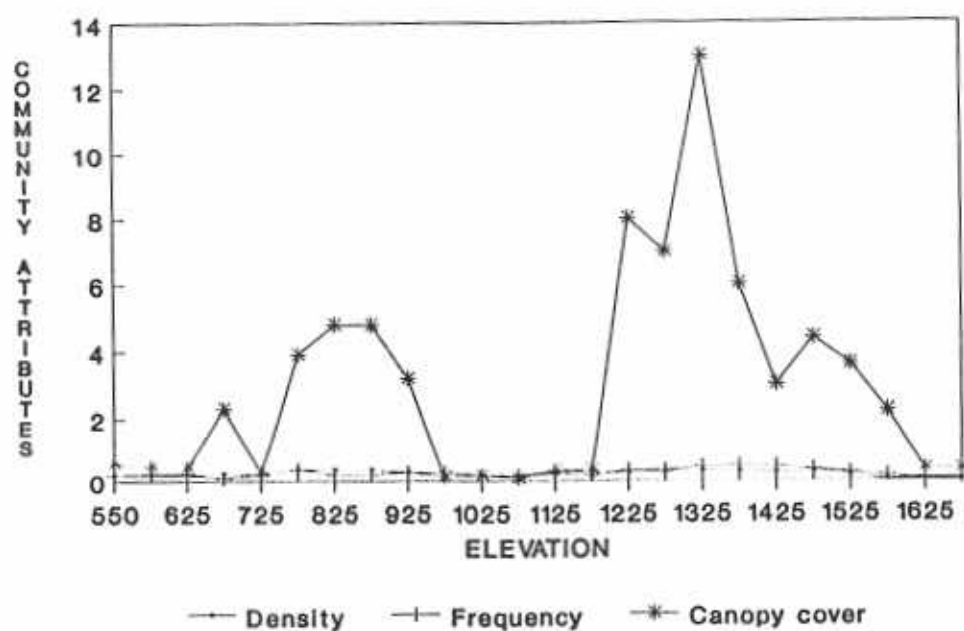
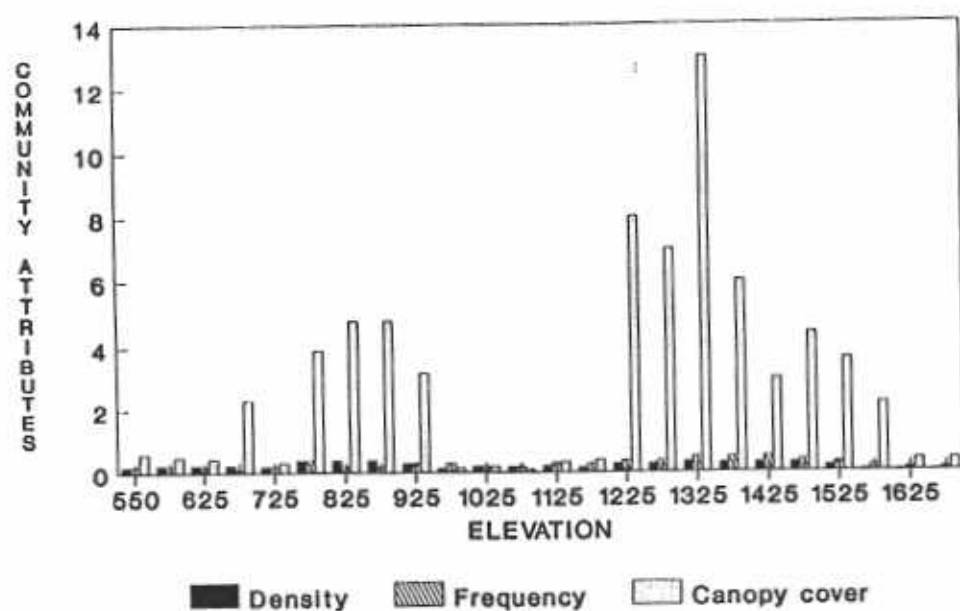


elevation, where Tanoor and Tangu Villages were situated, the topography changed into verticle cliffs. The 'edge effect' of the village was also very pronounced. Above 1200 m elevation the canopy values started increasing (Fig.4) hinting at the presence of large specimens. The value reached its peak at 1325 m elevation when again it started declining gradually mostly as a result of the shade effect of the pine zone which started at 1400 m elevation. As *P.roxburghii* began increasing in density and frequency, *D.viscosa* went on decreasing till at 1675 m elevation it reached its upper ecological amplitude.

Table 43 Community attributes vs elevation of *Dodoneae viscosa* on south facing slopes

Elevation	Density	Frequency	Canopy Cover
550	0.2	0.2	0.6
575	0.24	0.2	0.5
625	0.24	0.2	0.45
675	0.25	0.1	2.3
725	0.21	0.21	0.32
775	0.4	0.4	3.9
825	0.4	0.2	1.8
875	0.4	0.2	4.8
925	0.3	0.3	3.2
975	0.15	0.3	0.15
1025	0.2	0.2	0.2
1075	0.2	0.2	0.1
1125	0.22	0.32	0.35
1175	0.16	0.28	2.4
1225	0.28	0.38	8.0
1275	0.29	0.38	7.0
1325	0.35	0.5	13.001
1375	0.31	0.51	6.0
1425	0.3	0.5	3.0
1475	0.3	0.4	4.4
1525	0.2	0.3	3.6
1575	0.05	0.2	2.2
1625	0.03	0.1	0.4
1675	0.03	0.1	0.4

FIG.4 Community attributes vs elevation
Dodonaea viscosa (South Facing)



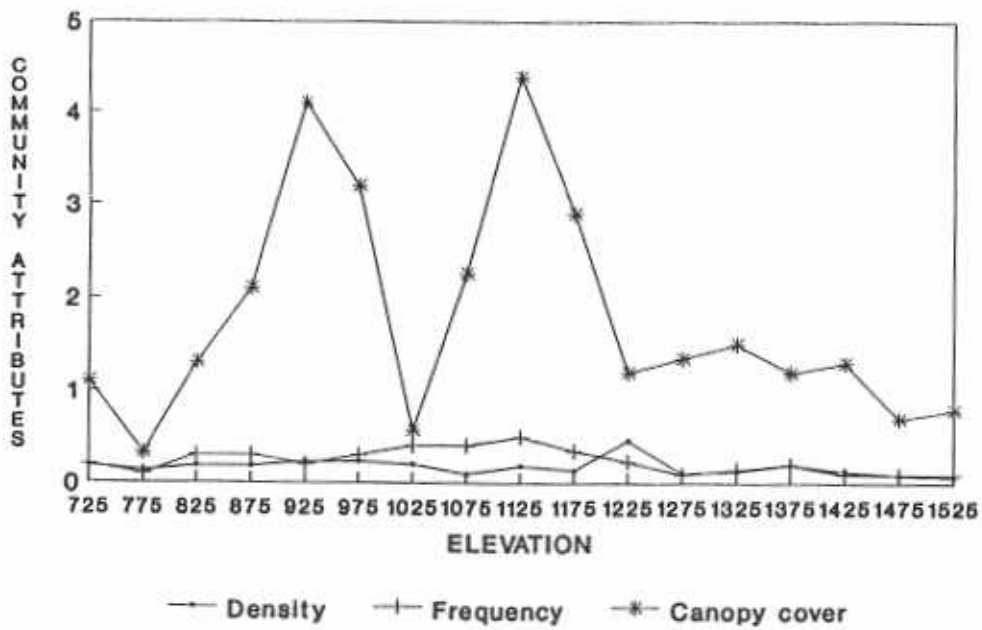
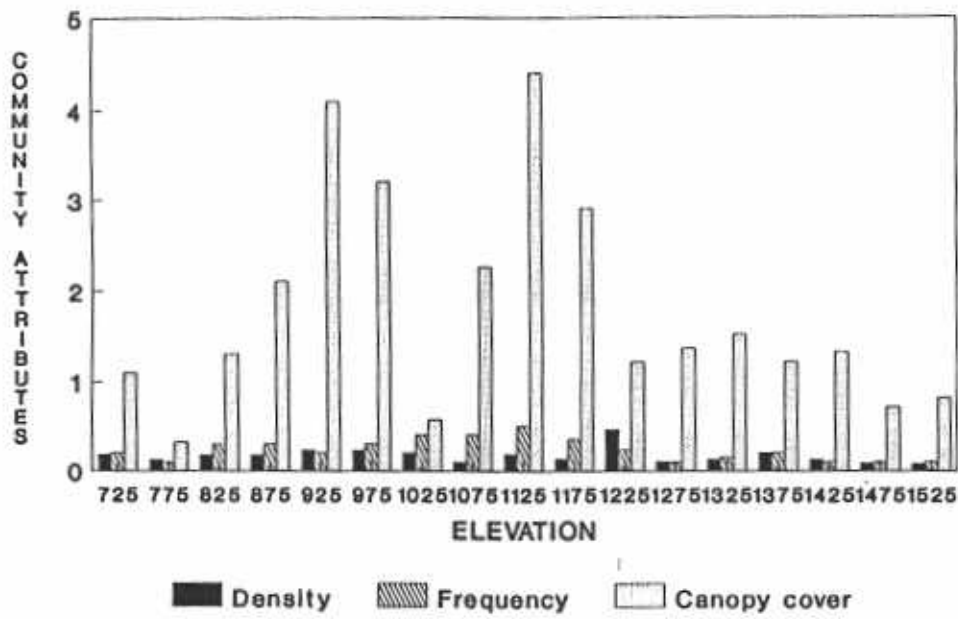
On the east-facing aspect of the mountain *D. viscosa* started at 725 m elevation and ended at 1525 m (Table 44). The general girth size of *D. viscosa* on the three aspects was between less than 5 to 20 cm CBH but on the slopes of east facing aspect it shot up to 25 cm and the largest sizes were found on the lower slope of the south facing aspect which were upto 35 cm CBH (Fig 5). These large size plants were those which had escaped cutting due to their occurrence in inaccessible or difficult locations and hint at the fact that, if left to itself, *D. viscosa* can attain the stature of a small size tree. The number of plants on the upper slope of ^{South} east-facing aspects was very low due to high altitude while in the corresponding east facing slopes they were totally absent obviously due to both altitude and aspect effects. In all the communities the presence of a large number of saplings and of almost all size classes reflect upon the self perpetuating and higher successional status of the plant.

Some very large size plants were uniformly distributed at 925 m and 1125 m elevations due to the presence of comparatively better developed soil. At 1025 m elevation the topography was flat but rocky with some patches of poorly developed soil and supported only a few small statured specimens of *D. viscosa*. It was also a disturbed area due to the presence of a few Gujar huts. At 1225 m elevation and beyond, just like the south-facing aspect, *D. viscosa* started dwindling due to thickening of the pine zone which had started at a lower elevation on this aspect.

Table 44 Community attributes vs elevation of *Dodoneae viscosa* on east facing slopes

Elevation	Density	Frequency	Canopy Cover
725	0.19	1.20	1.10
775	0.13	0.10	0.32
825	0.18	0.30	1.30
875	0.18	0.30	2.10
925	0.23	0.20	4.10
975	0.23	0.30	3.20
1025	0.23	0.40	0.57
1075	0.10	0.40	2.25
1125	0.19	0.50	4.40
1175	0.14	0.35	2.90
1225	0.46	0.23	1.20
1275	0.11	0.10	1.35
1325	0.13	0.15	1.50
1375	0.20	0.20	1.20
1425	0.13	0.10	1.30
1475	0.09	0.10	0.70
1525	0.08	0.10	0.80

FIG.5 Community attributes vs elevation
Dodonaea viscosa (East Facing)



2. *MALLOTUS PHILIPPENSIS*

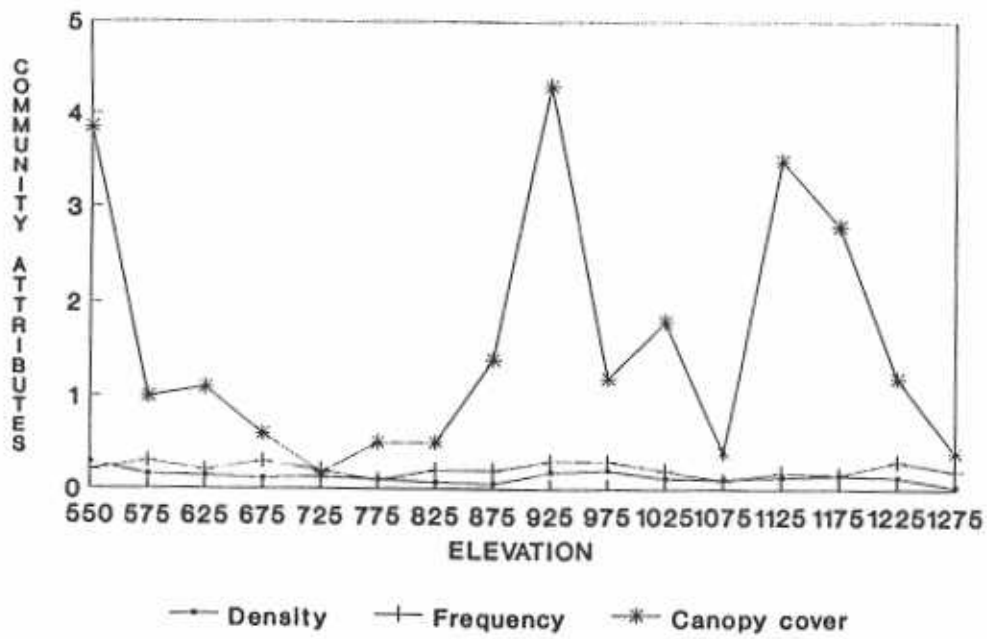
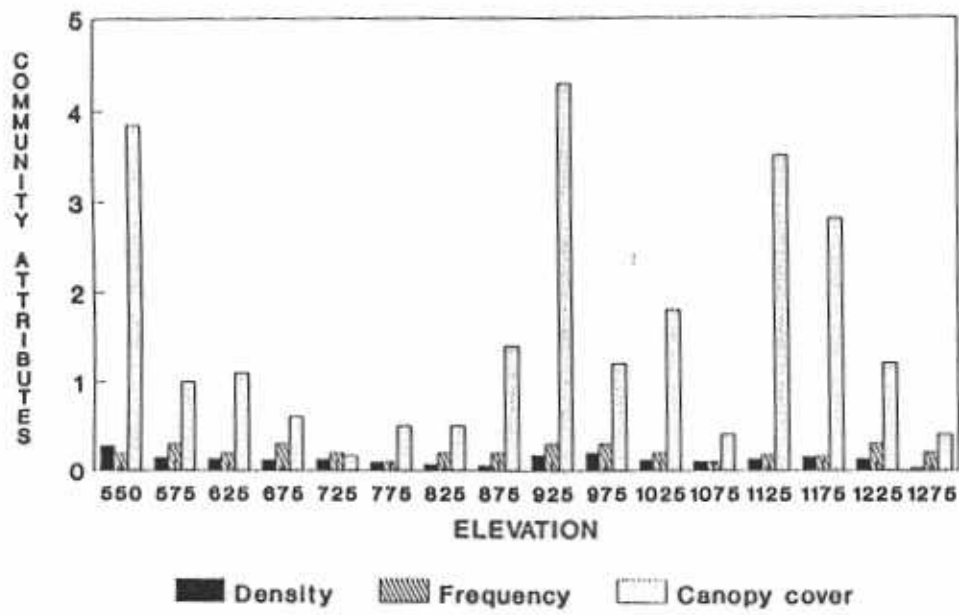
This plant occupied the first dominant position from the arborescent layer in 7 different communities (Table 41). It covered all the lower slopes and had quite often entered the pine zone where it constituted part of the understorey vegetation. The plant can withstand considerable amount of shade (Troup, 1921) and reproduces by suckers after being chopped for fuel wood. Due to its immunity from grazing (Parker, 1956) it is abundantly found in grazing and other wastelands. *M.philippensis*, basically, is a small sized tree but, when cut down, it develops the thick bushy form which casts large shades and is reported not to allow grasses to grow beneath it (Troup, 1921). This may either be due to allelopathy, shade effect or both. *Dodonaea viscosa* on the other hand, is a plant of exposed dry places. They, therefore, occupy different non overlapping niches and can flourish well together.

At the base of the north-facing aspect *M.philippensis* was represented by some large size specimens due to closeness to water in the ravine (Fig.6). They abruptly declined in density and size till 875 m elevation (Table 45) where the metalled road with its heavy traffic was passing through. Beyond this elevation the pine zone started but *M.philippensis* is tolerant of shade. A large dry nullah formed by the downwardly rushing rain water was present and *M.philippensis* not only thickly populated both the banks and the bed of the stream but had grown into large size bushes or even small tree. The plant, however, started decreasing with the increase in elevation till the top reached at 1350 m.

Table 45 Community attributes vs elevation of *Mallotus phillipensis* on north facing slopes

Elevation	Density	Frequency	Canopy Cover
550	0.28	0.20	3.85
575	0.15	0.30	1.00
625	0.14	0.20	1.10
675	0.12	0.30	0.60
725	0.13	0.20	0.17
775	0.10	0.10	0.50
825	0.07	0.20	0.50
875	0.06	0.20	1.40
925	0.18	0.30	4.30
975	0.20	0.30	1.20
1025	0.12	0.20	1.80
1075	0.11	0.10	0.40
1125	0.13	0.18	3.50
1175	0.15	0.16	2.80
1225	0.13	0.30	1.20
1275	0.03	0.10	0.40

FIG.6 Community attributes vs elevation
Mallotus philippensis (North Facing)

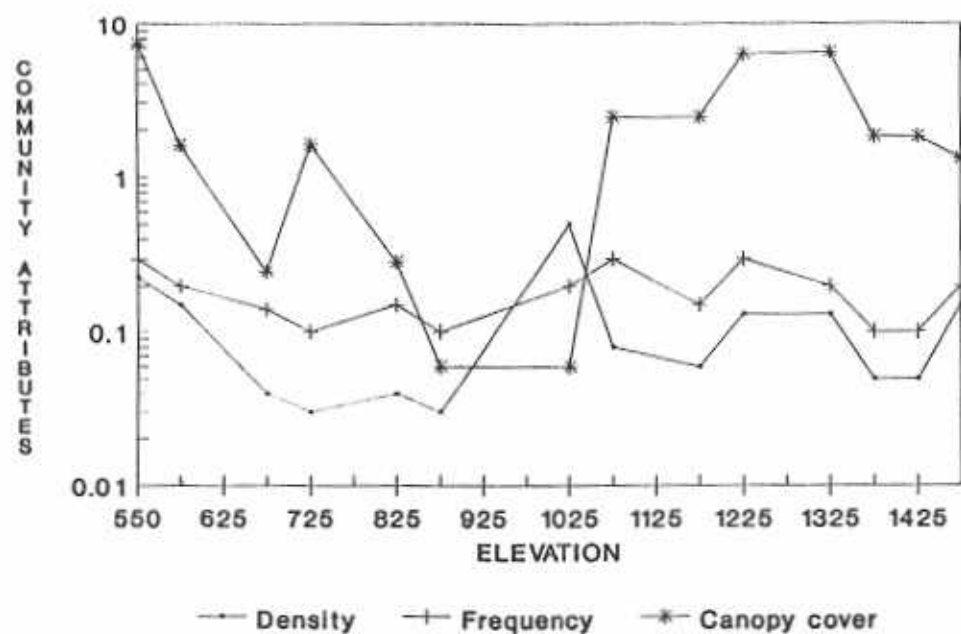
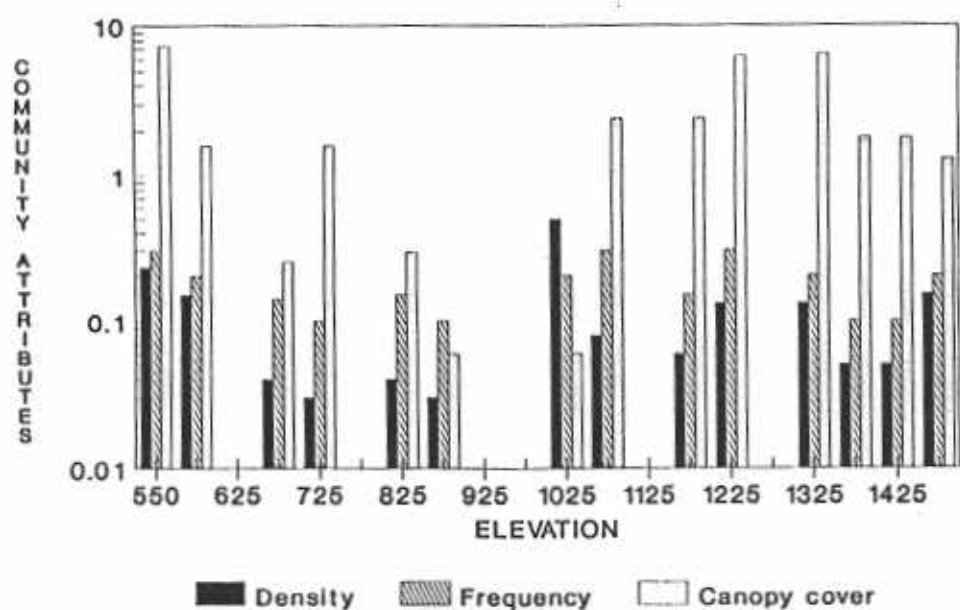


On the south-facing aspect the density, frequency and canopy coverage values were very high at the base of the mountain flanking the ravine (Table 46). The canopy cover values were the highest (Fig.7) hinting at the presence of very large size plants. These values started decreasing with elevation and exposure while *D.viscosa* and other woody plants of exposed area started increasing. However *M.philippensis* would acquire high density and canopy cover values on the banks of dry or perennial streams. Very low values were recorded between 825 m and 925 m elevation. This zone was highly degraded and exposed with a steep gradient and little soil cover. Although *D.viscosa* was doing well *M.philippensis* could not get firm footings there. Between 1025 m and 1175 m elevation the perpetual presence of moisture from the water fall helped the three community attributes of *M.philippensis* to increase. However, at 1200 m the plant started dwindling due to the chopping effect and other biotic pressures of the inhabitants of Tangu and Tanoor villages. The species was totally absent at 1275 m elevation. Beyond this point it again started increasing and entered the pine zone at 1400 m but at about 1500 m elevation it reached its upper ecological amplitude and gave in to *D.viscosa*, *Berberis lycium* and other understorey vegetation of the upper zone.

Table 46 Community attributes vs elevation of *Mallotus philippensis* on south facing slopes

Elevation	Density	Frequency	Canopy Cover
550	0.23	0.30	7.40
575	0.15	0.20	1.60
625	0.00	0.00	0.00
675	0.04	0.14	0.25
725	0.03	0.10	1.60
775	0.00	0.00	0.00
825	0.04	0.15	0.29
875	0.03	0.10	0.06
925	0.00	0.00	0.00
975	0.00	0.00	0.00
1025	0.50	0.20	0.06
1075	0.08	0.30	2.40
1125	0.00	0.00	0.00
1175	0.06	0.15	2.40
1225	0.13	0.30	6.30
1275	0.00	0.00	0.00
1325	0.13	0.20	6.50
1375	0.05	0.10	1.80
1425	0.05	0.10	1.80
1475	0.15	0.20	0.30

FIG.7 Community attributes vs elevation
Mallotus philippensis (South Facing)

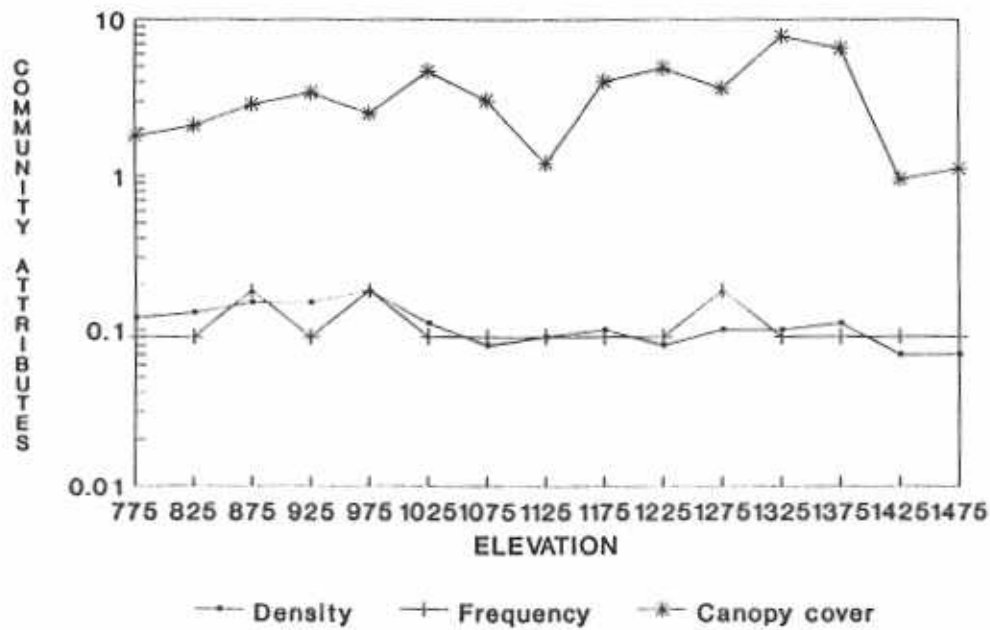
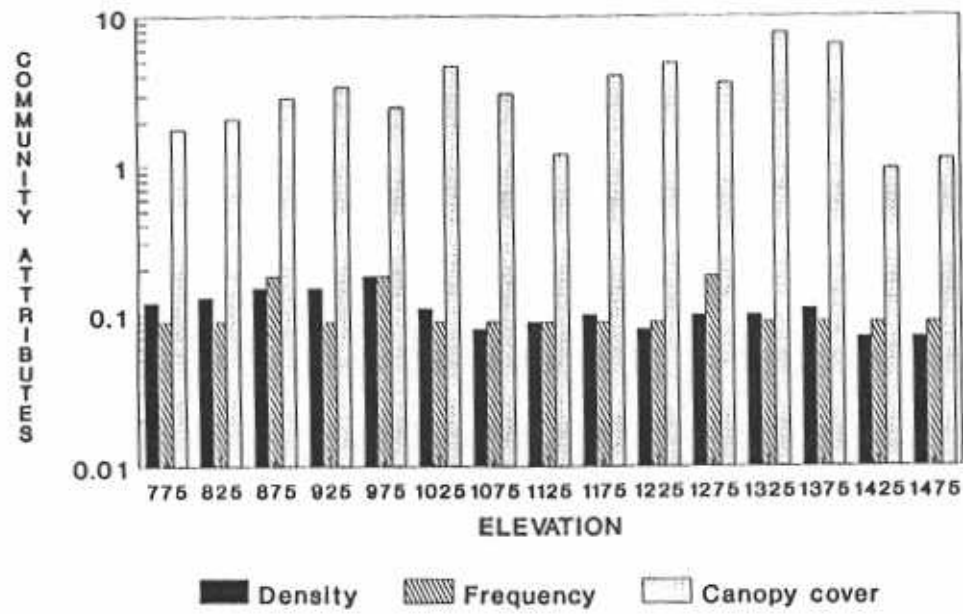


On the east-facing aspect *M.philippensis* occurred from the base to about 1500 m elevation. This is also the upper ecological limit of the plant (Troup, 1921). From the base to about 1025 m elevation the density and frequency values were high pointing at a large number of plants distributed uniformly in the area but the plants were young and immature as indicated by comparatively lower values of the canopy cover (Table 47; Fig.8). Beyond 1025 m elevation the flat topography and presence of spring water gave a tree stature to the plant with very high canopy cover values. At about 1125 m elevation the biotic interference due to the presence of Gujar huts was quite apparent on this plant which was found intensively cut down but beyond this the aspect became more shady, mesic and more favourable for the growth of *M.philippensis*. The canopy coverage values very much increased reaching its highest peak at 1375 m elevation but then the plant receded abruptly in density and canopy cover due to reaching its own upper ecological amplitude.

Table 47 Community attributes vs elevation of *Mallotus philippensis* on east facing slopes

Elevation	Density	Frequency	Canopy Cover
775	0.12	0.09	1.80
825	0.13	0.09	2.10
875	0.15	0.18	2.87
925	0.15	0.09	3.39
975	0.18	0.18	2.50
1025	0.11	0.09	4.66
1075	0.08	0.09	3.04
1125	0.09	0.09	1.20
1175	0.10	0.09	4.00
1225	0.08	0.09	4.86
1275	0.10	0.18	3.58
1325	0.10	0.09	4.72
1375	0.11	0.09	6.50
1425	0.07	0.09	0.95
1475	0.07	0.09	1.10

FIG.8 Community attributes vs elevation
Mallotus philippensis (East Facing)



M.philippensis occurred on the lower and middle slopes of all the three aspects. it was not found occupying a climax status at any site largely because of low rate of survival at places and the biotic interferences especially the fuel wood extraction. Its average girth size class was upto 40 cm CBH although plants as large as 55 cm CBH were also encountered on the lower south-facing slope (Table 14) which hints at its potential to develop into a large size tree, especially along nullah and water courses when left to itself.

3. *PINUS ROXBURGHII*

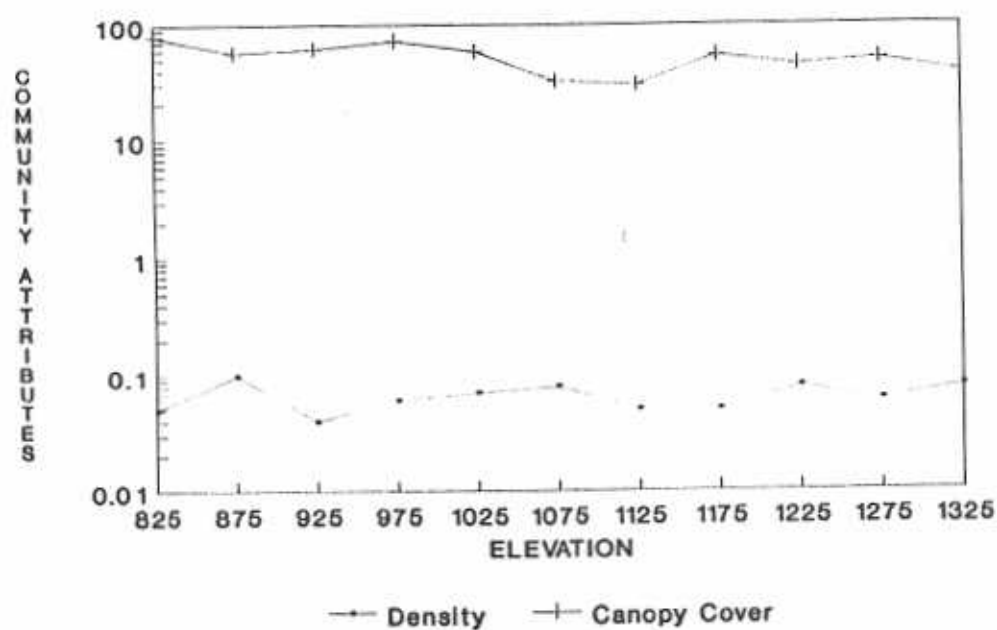
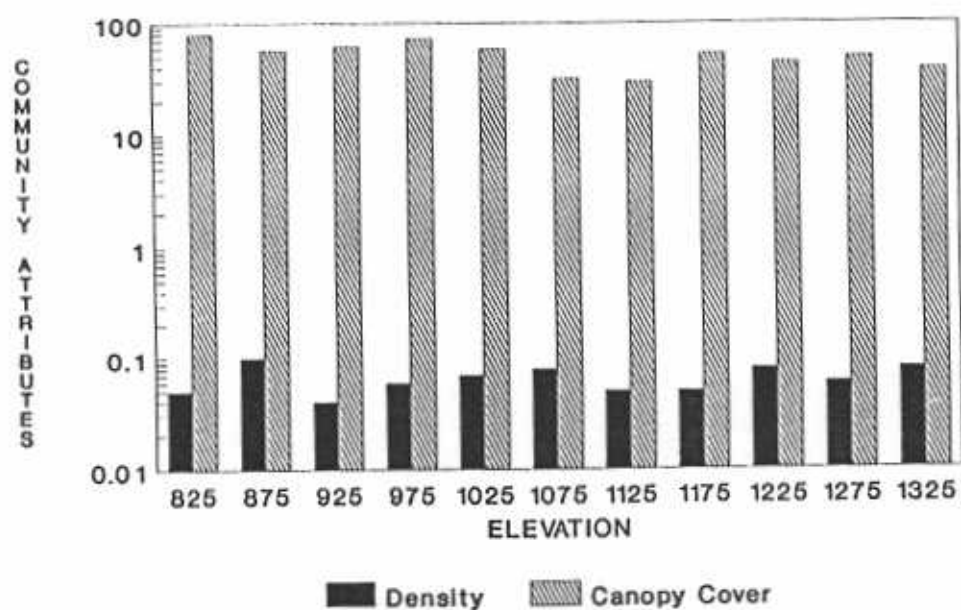
It had emerged as the leading dominant tree species in all the communities occurring on the middle and upper slopes (Table 41) and seemed to control the understorey vegetation through its large canopy cover while itself, it, is a strong light demanding plant in all stages of life (Troup, 1921).

On the north-facing aspect *Pinus roxburghii* started at about 825 m elevation and covered the aspect right upto the top (Table 48; Fig.9). Most of the large specimens were present from the base upto 1025 m elevation. The soil in this area was deep and well developed and the gradient comparatively low. Moreover, due to the vicinity of a check post they were probably better protected in the past as old trees were almost evenly met with.

Table 48 Community attributes vs elevation of *Pinus roxburghii* on north facing slopes

Elevation	Density	Canopy Cover
825	0.05	79.8
875	0.1	47.7
925	0.04	62.1
975	0.06	72.7
1025	0.07	59.2
1075	0.08	32.0
1125	0.05	21.9
1175	0.05	53.6
1225	0.08	44.4
1275	0.06	41.9
1325	0.08	38.3

FIG.9 Community attributes vs elevation
Pinus roxburghii (North Facing)

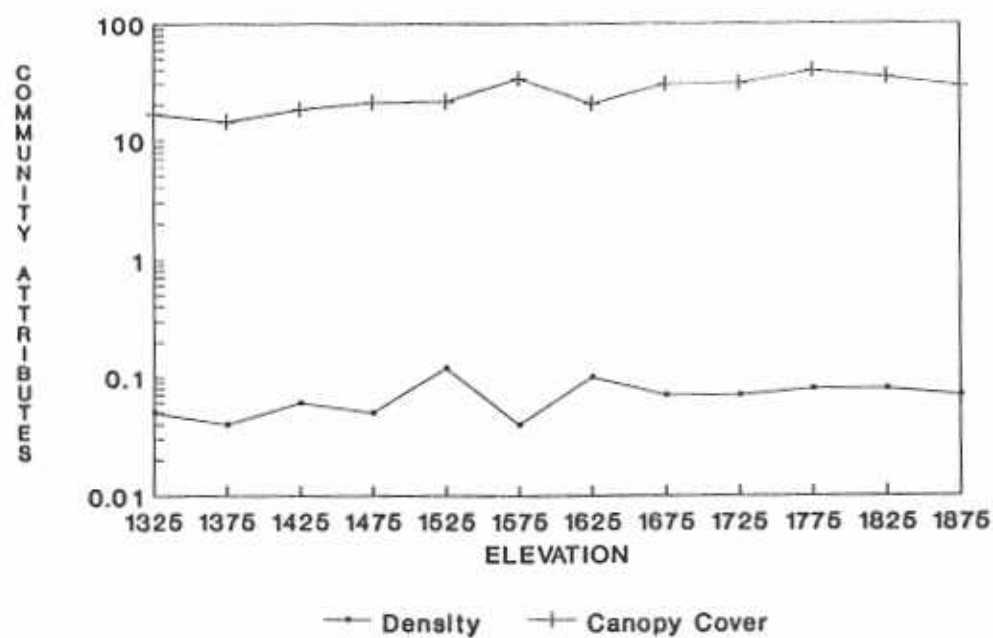
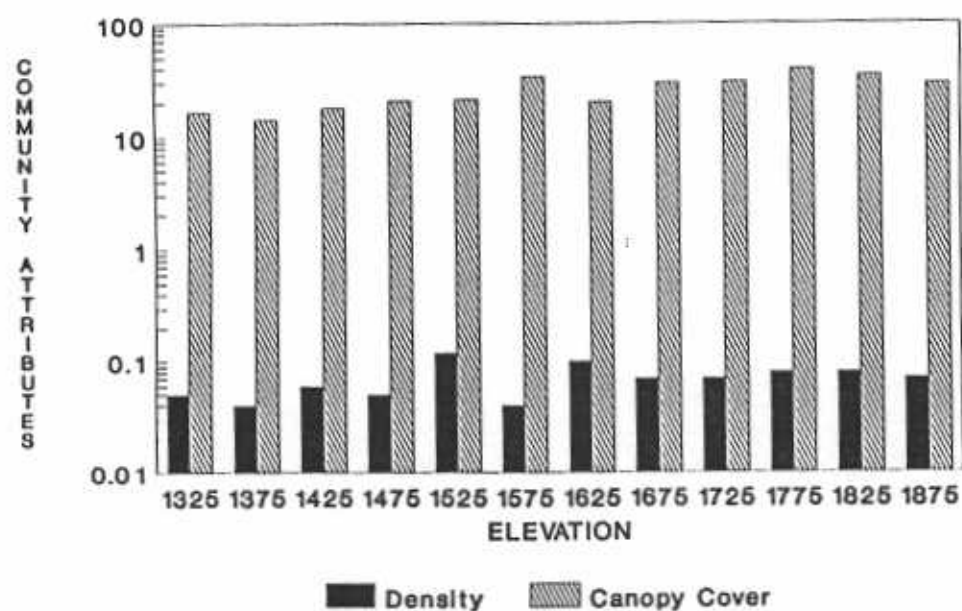


On the south-facing aspect *P. roxburghii* started at about 1325 m elevation beyond Tanoor Village (Table 49; Fig. 10) and covered it upto the top of Gishar Sar. The trend on this aspects was almost opposite to the north-facing aspect already discussed. The density was very low upto 1475 m elevation and so was the tree size. At 1575 m elevation the density was the lowest but the tree size was very large. From 1625 m ~~to~~ elevation upto the peak height the density as well as the tree size remained almost constant. The soil was well developed and the gradient was comparatively less steep. Rocks, talus and big boulders were commonly met with in this region.

Table 49 Community attributes vs elevation of *Pinus roxburghii* of south facing slopes

Elevation	Density	Canopy Cover
1325	0.05	16.7
1375	0.04	14.3
1425	0.06	18.1
1475	0.05	20.9
1525	0.12	21.2
1575	0.04	34.0
1625	0.10	20.3
1675	0.07	30.1
1725	0.07	30.4
1775	0.08	39.4
1825	0.08	34.8
1875	0.07	29.2

FIG.10 Community attributes vs elevation
Pinus roxburghii (South Facing)

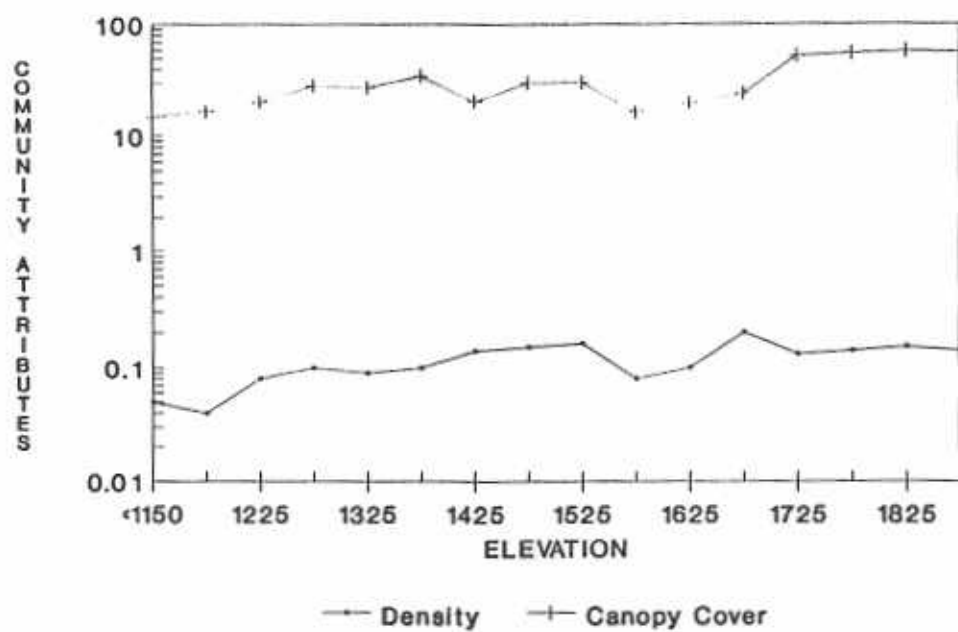
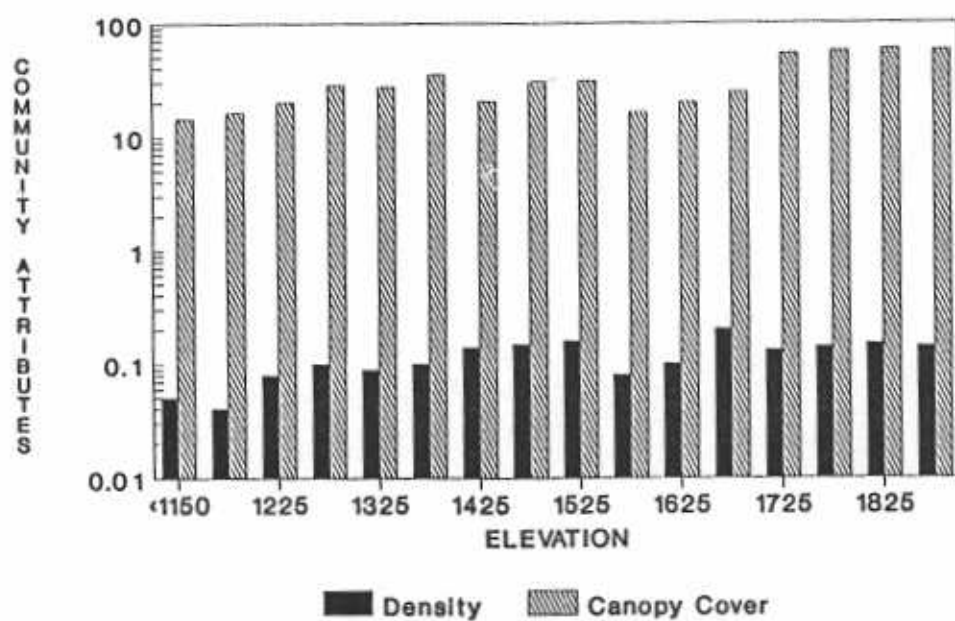


On the east-facing aspect the pine zone started at about 1150 m elevation and reached the base of Gishar Sar on this aspect at about 1875 m elevation (Table 50; Fig.11). Beyond this the gradient became almost verticle with 2 or 3 pines and a few *Quercus ilex* plants. The density was very low upto about 1175 m elevation. The gradient was very steep and the soil very little developed. Due to the rocky surface only a few pine plants could get soil for germination. At about 1225 m elevation the density started increasing and so did the tree size. Between 1575 m and 1625 m elevations pines were found heavily lumbered as a result of which their density dropped.

Table 50 Community attributes vs elevation of *Pinus roxburghii* on east facing slopes

ELEVATION	DENSITY	CANOPY COVER
1150	0.05	14.54
1175	0.04	16.38
1225	0.08	20.12
1275	0.10	28.35
1325	0.09	27.22
1375	0.10	34.93
1425	0.14	20.44
1475	0.15	30.46
1525	0.16	30.63
1575	0.08	16.24
1625	0.10	19.87
1675	0.20	24.24
1725	0.13	53.13
1775	0.14	56.45
1825	0.15	58.16
1875	0.14	67.34

FIG.11 Community attributes vs elevation
Pinus roxburghii (East Facing)



Pinus roxburghii covered the middle and upper slopes on all the three aspects.

Though it was also self perpetuating, its rate of survival was not uniform which hints at rather a bleak future for the plant in this region. A large number of plants were found chopped, lumbered and pollarded particularly those at the lower girth size classes as these have many domestic uses like making the frames of cots (Charpais) and as batten in the house construction. Hence a number of gaps were found in these size classes (Table 17). Also many large trees were found with their pilots cut off. Pines usually dry up when they loose their pilots in which case the local inhabitants are allowed to use them as firewood. Goat grazing was actually observed which resulted in the reduced number of the young specimens and the deformation of the older ones. Young saplings also get crushed due to trampling by the large size animals although those which survive it grow well. This may be one of the reasons of the presence of a lesser number of saplings though girth size classes more than 5.0 cm were better represented. Steps must be taken at this stage to increase both the germination and survival rate to save *P. roxburghii* from extermination from this area.

SPECIES DIVERSITY

Beside the few ecological dominants of a community, which no doubt largely control the energy flow in the trophic groups, a large number of rare species with much less importance values are also present and play an important role in the community set up. Species diversity is largely related to these rare species and may simply be defined as the ratio of the total number of species with the total number of individuals (Odum, 1971). Species diversity is related to community dynamics like stability, productivity, competition and maturity (Pielou, 1966, Poole, 1974) and is an important attribute reflecting upon the community organization. It is largely used for comparing structural characteristics of the communities (Hairston, 1959, 1964). It differs with different geographical areas, altitude, aspect, microclimates, soil and above all the degree of biotic interference (Pemadasa and Amarsinghe, 1982). Different seasons, successional stages and even sample size may be other factors affecting species diversity, but it is normally low in the physically controlled and young communities and high in the biologically controlled and stable communities (Odum, 1971). Over grazing reduces species diversity through the removal of all the palatable species but moderate grazing increases it by reducing the density of the dominant species thus giving chances to other plants to crop up (Harper, 1969). Man is also instrumental in reducing the species diversity through mono-culture as the diversity is inversely related to dominance (Shaukat *et al.*, 1978).

Species diversity has two major components; the species richness and the equitability or evenness (Krebs, 1978). The former is related to the number of species in a community and is used to compare different communities while the latter is the apportionment

of individuals among the species. Shannon-Wiener function combines these two into one overall index of diversity and is independent of the sample size (Odum, 1971). It has therefore been used in this study.

Species diversity was found strongly and positively correlated with its two components viz species richness and equitability (Table 51) and strongly and negatively correlated with dominance, density and coverage (Tables 52 & 53). These support the findings of other workers (Shaukat *et al.*, 1978; Braun, 1950; and McNaughton, 1968).

Table 51 Relationship of general diversity with its two components i.e. species richness and equitability of the spring communities of ambela pass, expressed as coefficient of linear correlation

Regression analysis are given below the table:

	Species richness (S)	Equitability (E)
Species Diversity (D)	+ 0.78	+ 0.92
D =	- 0.583 + 0.398 S	S = 2.34 + 1.536 D
D =	- 0.181 + 0.147 E	E = 0.458 + 5.741 D

Table 52 Values of density and coverage of the different plant communities of spring flora

Aspect/Community	Density	Coverage
<u>A. Aquatic vegetation</u>		
1. <i>Arundo-Mentha</i>	433.3	617.24
2. <i>Mentha-Nasturtium</i>	169.5	327.80
<u>B. North facing</u>		
1. <i>Mallotus-Dodonaea-Themeda</i>	51.9	186.9
2. <i>Pinus-Dodonaea-Micromera</i>	37.3	266.3
<u>C. South facing</u>		
1. <i>Dodonaea-Adhatoda-Gnaphalium</i>	54.2	307.3
2. <i>Mallotos-Dodonaea-Themeda</i>	46.4	383.3
3. <i>Pinus-Dodonaea-Rumex</i>	43.6	393.5
4. <i>Pinus-Berberis-Geranium</i>	38.3	152.0
<u>D. East facing</u>		
1. <i>Mallotus-Dodonaea-Themeda</i>	32.8	333.8
2. <i>Pinus-Dodonaea-Oxalis</i>	46.4	305.7
3. <i>Pinus-Berberis-Geranium</i>	37.1	179.7

Table 53 Correlation coefficient of linear correlation between general species diversity (g), species richness (s) and equitability (e) with density (a), coverage (b) and dominance (c) of the communities of spring flora of Ambela pass. Regression equations are given below the table.

	Density (a)	Coverage (b)	Dominance (c)
General special diversity (g)	- 0.933	- 0.829	- 0.94
Species richness (s)	- 0.656	- 0.636	- 0.68
Equitability (e)	- 0.902	- 0.758	- 0.62

g = 558.2 - 125.6 a	:	a = 4.351 - 6.934 g
s = 246.54 - 173.41 a	:	a = 1.126 - 0.002 s
e = 642.84 - 758.51 a	:	a = 0.825 - 1.072 e
g = 760.2 - 119.8 b	:	b = 5.526 - 5.732 g
s = 476.71 - 180.37 b	:	b = 1.606 - 2.240 s
e = 813.2 - 685.1 b	:	b = 0.992 - 8.39 e
g = 0.716 - 0.152 c	:	c = 4.588 - 5.812 g
s = 0.34 - 0.22 c	:	c = 1.22 - 2.15 s
e = 0.16 - 0.58 c	:	c = 0.759 - 0.084 e

Among the 11 spring communities *Arundo-Mentha* community showed the highest value of index of dominance and the lowest value of species diversity (Table 54). Even this low value of the species diversity was mostly contributed by the equitability component; the species richness value was the lowest. The reason for all this seems to lie in the fact that the community belonged to the stream vegetation. The water flowed perpetually with minor temperature fluctuation occurring seasonally, otherwise other climatic factors remained more or less the same. *Arundo donax* is a perennial plant and once established, it flourishes well almost to the exclusion of other shade producing plants. The associated herbaceous flora may change seasonally but not much. The community thus has passed through successional changes and has reached a higher successional status containing only a few self perpetuating species.

The second aquatic community, namely *Mentha-Nasturtium* community, follows *Arundo-Mentha* community for the same reason.

The terrestrial communities occupying the upper slopes showed the highest species diversity. They were all situated in a thick pine zone which provided numerous microhabitats for a variety of species to grow. At the same time grazing here was moderate due to the scarcity of grasses and other palatable forbes. In these cases species richness rather than equitability component contributed more towards the species diversity.

These were followed by the communities occupying the middle slopes. These slopes were also dominated by *Pinus roxburghii* from the tree substratum but the forest was comparatively open allowing enough grasses and other palatable species to flourish well and to attract grazing animals. Other biotic interferences like cutting and lumbering were also very pronounced which may largely be responsible for a comparatively low species diversity. Species richness and equitability almost equally contributed towards the species diversity.

Table 54 Indices of Diversity, Dominance and Community Maturity of spring vegetation

No.	Aspect	Community	Size of Sample (m ²)	Number of Species	Number of Individuals	Community Maturity Index	Species Diversity			
							Simpson's Index of Dominance	Shannon - General	Wiener's Species Richness	Index Equitability
	Aquatic vegetation	<i>Arundo-Mentha</i>	990.00	17	4827	16.9436	0.3984	1.3724	0.1491	0.3358
	Aquatic vegetation	<i>Mentha-Nasturtium</i>	330.00	19	1774	11.0368	0.1548	3.0991	0.4511	0.7295
	North-facing (L.S)	<i>Mallotus-Dodonaea-Themeda</i>	935.00	39	3330	17.2103	0.1212	3.8149	0.6758	0.7218
	North-facing (M.S)	<i>Pinus-Dodonaea-Micromeria</i>	1792.50	54	4508	10.1204	0.0902	4.2921	0.8043	0.7491
	South-facing (L.M.S)	<i>Dodonaea-Justicia-Themeda</i>	1038.75	51	2321	11.8549	0.0816	3.7204	1.0586	0.6559
	South-facing (L.S)	<i>Mallotus-Dodonaea-Themeda</i>	783.75	40	1182	9.7075	0.1060	3.8372	1.1635	0.7210
7.	South-facing (M.S)	<i>Pinus-Dodonaea-Runex</i>	495.00	23	739	16.3913	0.0670	4.1095	0.8840	0.8055
8.	South-facing (U.S)	<i>Pinus-Berberis-Geranium</i>	783.75	40	885	10.8625	0.0920	4.6094	1.3446	0.8660
9.	East-facing (L.S)	<i>Mallotus-Dodonaea-Themeda</i>	742.50	27	908	9.7407	0.1030	3.6550	0.8960	0.7700
10.	East-facing (M.S)	<i>Pinus-Dodonaea-Oxalis</i>	1105.00	33	2330	19.21	0.1210	3.9340	0.6837	0.7024
11.	East-facing (U.S)	<i>Pinus-Berberis-Geranium</i>	493.75	42	536	13.00	0.0671	4.3590	1.8140	0.8084

L.M.S = Lowermost slopes

L.S = Lower slopes

M.S = Middle slopes

U.S = Upper slopes

The communities occupying all the lower slopes and that occupying the lowermost slope of the south-facing aspect showed the lowest species diversity on an average. In the communities occupying the south-facing aspect the contribution of the species richness component was very large as compared to the equitability component while in the other two aspects both species richness and equitability contributed almost equally towards the species diversity. The communities were highly disturbed biotically. Over grazing coupled with trampling and fuel wood extraction had damaged both the community as well as soil structure. As a result the species diversity values dropped down.

The same trend was observed in the general species diversity values of the fall communities as well (Table 55). Only these values were lower than those of the communities occupying the same slopes in the spring. The obvious reason was the low number of species as well as individuals of the species in the fall than the spring season. Generally speaking the species richness and equitability components contributed almost equally to the species diversity.

With regard to the aquatic vegetation the first community was wholly dominated by *Arundo donax* leaving few habitats for other species to occupy. Most of the dominance was reposed in this one species. As a result the general species diversity alongwith its two components dropped to very low as compared to the second aquatic community in which the dominance was distributed proportionately among all the species.

Table 55 Indices of Diversity, Dominance and Community Maturity of fall vegetation

No.	Aspect	Community	Size of Sample (m ²)	Number of Species	Number of Individuals	Community Maturity Index	Species Diversity			
							Simpson's Index of Dominance	Shannon - General	Wiener's Species Richness	Index Equitability
1.	Aquatic vegetation	<i>Arundo-Nasturtium</i>	12.5	19	4013	16.79	0.3939	1.9580	0.3000	0.4609
2.	Aquatic vegetation	<i>Nasturtium-Mentha</i>	10.0	14	1027	21.99	0.1876	2.8614	0.4369	0.7503
3.	North-facing	<i>Mallotus-Dodonaea-Poa</i>	742.5	23	1281	24.97	0.1843	3.0084	0.6426	0.6651
4.	North-facing	<i>Pinus-Dodonaea-Setaria</i>	810.0	35	2925	16.27	0.1261	3.5667	0.7396	0.7214
5.	South-facing	<i>Mallotus-Helicteres-Oxalis</i>	720.0	21	980	25.67	0.1555	3.1619	0.6708	0.7199
6.	South-facing	<i>Mallotus-Dodonaea-Oxalis</i>	825.0	28	1471	19.86	0.1339	3.5365	0.7300	0.7356
7.	South-facing	<i>Pinus-Dodonaea-Micromeria</i>	450.0	22	686	27.32	0.1255	3.4962	0.8400	0.7840
8.	South-facing	<i>Pinus-Berberis-Oxalis</i>	682.5	28	1221	22.18	0.1117	3.8823	0.8013	0.7660
9.	East-facing	<i>Mallotus-Dodonaea-Aristida</i>	630.0	26	853	18.5400	0.0882	3.5274	0.8900	0.8143
10.	East-facing	<i>Pinus-Dodonaea-Oxalis</i>	630.0	25	1152	26.07	0.1027	3.7900	0.7366	0.8161
11.	East-facing	<i>Pinus-Berberis-Oxalis</i>	360.0	24	651	26.96	0.1221	3.9302	0.9406	0.8506

Meadows are almost flat lands distinguished only on the basis of their location on different elevations. As such the aspect effect was absent. Only the elevation effect expressed itself in the change of kinds of species only. Other factors like grazing etc were the same. Hence no great difference in the values of species diversity or its two components could be observed. However in all the meadows, both of spring and fall, the equitability component contributed more than the species richness component towards the general species diversity because of the uniformity of the habitat. (Tables 56 and 57).

Table 56 Indices of Diversity, Dominance and Community Maturity of spring vegetation of the Meadows

S.No. Aspect	Community	Size of Sample (m ²)	Number of Species	Number of Individuals	Community Maturity Index	Species Diversity			
						Simpson's Index of Dominance	Shannon - General	Wiener's Species Richness	Index Equitability
1.	<i>Oxalis-Gnaphalium</i> (1190 m)	10.0	15	2023	36.4667	0.2277	2.7650	0.3330	0.7100
2.	<i>Salvia-Oxalis-Gnaphalium</i> (410 m)	12.5	16	2511	51.1875	0.2070	2.7570	0.3190	0.6900
3.	<i>Filago-Oenothera-Cynodon</i> (1580 m)	10.0	16	1989	28.8125	0.2696	2.8620	0.3590	0.7160

Table 57 Indices of Diversity, Dominance and Community Maturity of fall vegetation of the Meadows

S.No. Aspect	Community	Size of Sample (m ²)	Number of Species	Number of Individuals	Community Maturity Index	Species Diversity			
						Simpson's Index of Dominance	Shannon - General	Wiener's Species Richness	Index Equit-Ability
1.	<i>Cannabis-Cynodon</i> (1110 m)	10.0	14	1202	22.7857	0.3870	1.8730	0.4040	0.4920
2.	<i>Poa-Setaria</i> (1410 m)	10.0	11	1363	30.0909	0.3150	2.1050	0.2980	0.6090
3.	<i>Cynodon-Cyperus</i> (1580 m)	10.0	12	746	39.3334	0.3840	2.7900	0.4390	0.7780

CONCLUSIONS

The area is highly disturbed and degraded due to biotic factors. Man is thoroughly busy in removing the vegetation for fuel wood and the procurement of agricultural land through slashing and burning particularly at higher elevations. In fact these mountains are privately owned and are auctioned every year for the extraction of fuel wood which includes *Dodonaea viscosa*, *Mallotus philippensis* and a few other species. Even pines are not spared and are pollarded for domestic use. A more serious menace is the overgrazing by heavy ungulates which not only remove the vegetation cover but, through trampling effects, destroy it and make the soil prone to erosion by disturbing and breaking it. Goat grazing is, in particular, a potential danger to the young saplings and older vegetation equally. The forests, both coniferous and scrub, are in poor condition. They exhibit considerable variation in age class distribution and show poor regeneration. The pine crop is particularly patchy with poor survival rate and is malformed.

If the interferences could, somehow, be controlled, the local vegetation will definitely take a turn towards improvement and may adopt the following pattern:

The lower slopes of all the aspects will be covered with *Dodonaea viscosa*, *Mallotus philippensis* and *Justicia adhatoda*. Mixed with these will be *Acacia modesta* and *Sageretia thea* var. *brandrethiana*. In addition to these, some species will mostly be confined to the different slopes only. For example the north-facing lower slopes will support *Carissa opaca*, *Mimosa himalayana*, *Debregeasia salicifolia* and *Myrsine africana* (Table 14). Most of them may attain large bushy sizes due to the prevalence of more favourable conditions here. Similarly

on the lower slopes of the south-facing aspect *Cassia fistula*, *Celtis australis*, *Flacourtia indica*, *Helicteres isora*, *Maytenus royleanus*, *Olea ferruginea*, *Zanthoxylum alatum*, *Zizyphus nummularia*, *Z. oxyphylla* and a few specimens of *Phoenix humilis* will be found scattered all over. Out of these *O. ferruginea* has the potential to reproduce and flourish as indicated by the presence of specimens of all girth classes ranging from less than 5.0 to 25.0 cm (Table 14). The main reason that they could not attain tree size was grazing and browsing as the plant is highly palatable at young stage. Other environmental conditions are very conducive for its growth (Khan, 1963; and Troup, 1921). If these biotic interferences could be checked, the plant may flourish very well.

The lower slopes on the east-facing aspect will, in addition to *D. viscosa* and *M. philippensis*, include *Maytenus royleanus*, *Zizyphus oxyphylla* and *Z. nummularia*. Some saplings of *Zanthoxylum alatum* and *O. ferruginea* were also encountered on this slope. As such these may join the others at a later stage if the micro-climate is favourably modified by the absence of grazing and other biotic interferences.

On the middle slopes of all the aspects *Pinus roxburghii* will remain the dominant tree but *M. philippensis*, being a shade tolerant species, may increase in number and size and attain a co-dominant position with the former. *Dodonaea viscosa* will remain the dominant understorey shrub but other plants like *Berberis lycium*, *Carissa opaca*, *Sageretia thea* var. *brandrethiana* and *Zanthoxylum alatum* may accompany it (Table 17). In addition to these common species, the following will be particularly associated with their different aspects.

- a. North-Facing Aspect: *Debregeasia salicifolia* and *Zanthoxylum alatum*.
- b. South-Facing: *Olea ferruginea* and *Quercus incana*.
- c. East-Facing: *Maytenus royleanus*, *Quercus incana* and *Zanthoxylum alatum*.

On the upper slopes of the south- and east-facing aspects, *Pinus roxburghii* will not only retain its dominant position from the tree substratum but will rather increase its number and girth size as the conditions here are very conducive for its germination and growth (Parker, 1956). But some definite measures must be adopted to improve them. *Berberis lycium* and *Indigofera heterantha* with a lesser number of *Dodonaea viscosa* will constitute the shrub layer (Table 17). In addition to these *Carissa opaca*, *Quercus incana* and *Ficus palmata* may join on the south facing slopes and *Maytenus royleanus*, *Quercus incana* and *Zanthoxylum alatum* may be found interspersed with the common species on the east-facing upper slopes.

The research area has been so much disturbed that no arborescent dominant species shows the trends of forming a climax vegetation. In case the disturbances are controlled, *Pinus roxburghii*, *Mallotus philippensis* and *Dodonaea viscosa* may become the climax species.

RECOMMENDATIONS

In order to improve the vegetation of the area, soil conservation practices should be introduced, supply of water be regulated and wildlife of the area be preserved and improved. At the same time the requirements of fire-wood, timber, cattle grazing, grass collection etc. of the local population may be met by adopting the following measures:-

1. The area should be closed to grazing, browsing and fuelwood extraction at least for five years. If the entire area cannot be closed at one time different sites should be selected for rotation grazing. During the closing period grass cutting by sickle may be allowed but animal grazing and trampling should be completely banned for the period.
2. Sporadic and controlled fires may be allowed to remove the pine needles and other debris. This will not only allow the fallen seeds to make contact with the soil for germination but the ash so obtained may increase the fertility of the soil. Heavy and frequent fires, however, must be avoided in order to protect the pine forest.
3. Artificial plantation of pine may be carried out either through nurseries or direct seed sowing. In the latter case best quality seeds must be obtained. The saplings must be well protected during the early stages.
4. In order to check erosion, the bare areas, land slips and banks of nullahs must be planted preferably with fast growing broad leaved species for quick

stabilization of the area. Utmost care must be taken in the selection of the quick growing exotic species, as some of these may prove invasive and aggressive and may destroy or even eliminate the local flora. Therefore, local species should always be given first priority.

Construction of check dams, terraces, gully plugging and other soil conservation methods must be adopted to check erosion.

In achieving all this, the rights and privileges of the local people must be protected as without their cooperation any of the above schemes will never be fruitful.

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